HYDRO-ELECTRIC INQUIRY COMMISSION

ENGINEERING DATA

THE QUEENSTON-CHIPPAWA POWER DEVELOPMENT

CHAPTER "J"—QUANTITIES
BRIDGES AND CROSSINGS

WALTER J. FRANCIS, C. E.
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Chapter J.

~~QUATTWIG~~

(Bridges and Crossings)

Walter J. Francis

Chapter 7.

(Marriages and Dissolutions)

Walter J. Francis

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Bridges and Crossings Section

Copy for Enclosure to Mr. G. Alton Ross.

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Chapter J.

QUANTITIES

Walter J. Francis

The first part of Chapter J, being pages J-1 to J-45, refers to quantities in the right-of-way, and the second part, being pages J-46 to J-99, refers to temporary buildings and commissariat for construction. The present portion is devoted to bridges and wire crossings over the power canal of the Queenston-Chippawa Power Development.

BRIDGES AND CROSSINGS.

General.

The construction of the Power Canal of the Queenston-Chippawa Power Development necessitated the re-construction of one highway and one railway bridge over the Welland River and the construction of seven highway bridges and four railway bridges over the Canal. The Canal actually crossed the location of fourteen roads and streets but, by negotiations with the municipalities concerned, several original road allowances were closed or diverted, and the number of highway bridges required reduced to a total of eight as above. An additional highway bridge will be necessary at the northern end of the Canal on the completion of the new Park Boulevard. It was also necessary to provide crossings of the Canal for the power, telegraph and telephone lines, of which crossings there are thirty-two.

During the construction of the permanent highway and railway bridges it was necessary to provide temporary bridges to take care of the traffic. Seven such bridges were constructed and these have now been dismantled on completion of the permanent structure.

In addition to the bridges required across the Welland River and the Canal of a more or less permanent character, there were six temporary bridges constructed for grade separation of highways and the construction railway, and for construction railway and construction road crossings of the Canal.

The number and nature of the bridges and crossings dealt with in this Chapter are as follows:-

(1) Highway Bridges - Four permanent structures,
Four temporary structures which will be utilized during their life and then replaced by a permanent structure.

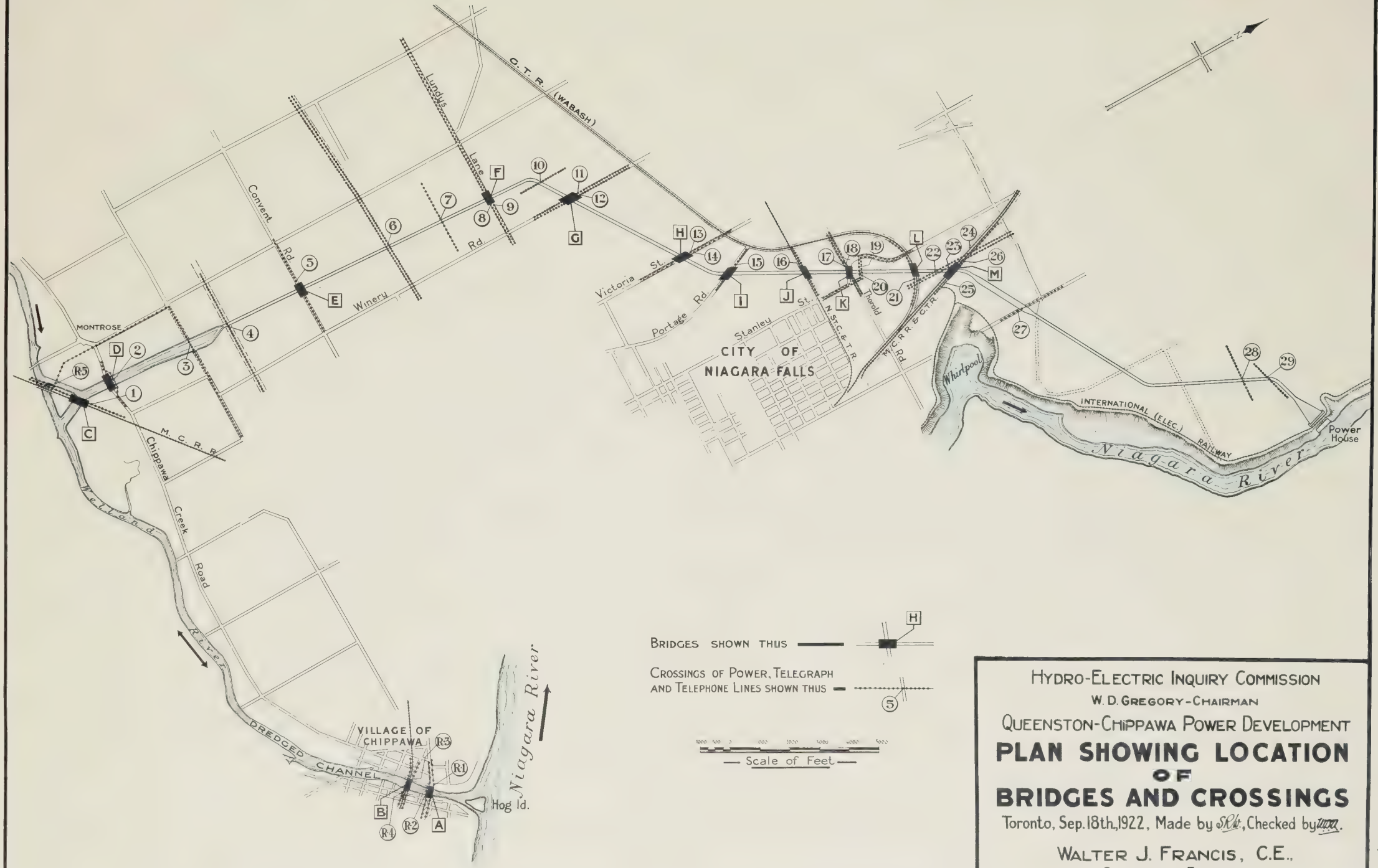
(2) Railway Bridges - Five permanent structures.

(3) Wire Crossings - Thirty-two installations.

The locations of the above bridges and crossings are shown generally on the map included herewith as page J-102, and entitled "Plan Showing Location of Bridges and Crossings". On the map the locations of the bridges constructed by the Hydro-Electric Power Commission are designated by a reference letter and the locations of the wire crossings which were diverted or reconstructed are shown by a reference number.

Highway Bridges.

The following table gives a list of the Highway bridges over the Welland



HYDRO-ELECTRIC INQUIRY COMMISSION

W. D. GREGORY - CHAIRMAN

QUEENSTON-CHIPPAWA POWER DEVELOPMENT

PLAN SHOWING LOCATION OF BRIDGES AND CROSSINGS

Toronto, Sep. 18th, 1922, Made by SKW, Checked by WWW.

WALTER J. FRANCIS, C.E.,

CONSULTING ENGINEER

(J-102)

River and the Canal which were agreed upon by the Hydro-Electric Power Commission in negotiations with the Municipalities concerned, with the location, type and present condition of each. Stations referred to under Location are the Canal centre line chainages.

Table of Highway Bridges.

Reference Letter on Key Plan	Bridge	Location	Type for Permanent Structure	Present Condition
A.	Bridgewater Street	Chippawa	Steel Bascule	Completed.
D.	Chippawa Creek Road	Sta. 23+00	Not decided	Temporary Trestle.
E.	Convent Road	Sta. 86+00	Steel Truss	Temporary Trestle.
F.	Lundys Lane	Sta. 162+00	Steel Truss	Under construction.
G.	Winery Road	Sta. 192+00	Steel Truss	Temporary Trestle.
H.	Victoria Street	Sta. 232+00	Steel Truss	Temporary Trestle.
I.	Portage Road	Sta. 249+00	Steel Truss	Under construction.
K.	Thorold Road	Sta. 289+00	Steel Truss	Under construction.

Negotiations regarding the highway crossings of the proposed Canal were commenced in the Fall of 1917, and on November 19th of that year the engineers of the Hydro-Electric Power Commission submitted plans to the Township showing the bridges designed as concrete arches with wing walls and earth filling.

On March 18th, 1918, an agreement was entered into with the Municipalities providing for the bridges to be built; the roads to be diverted or closed; and the road allowances to be ceded to the Hydro-Electric Power Commission. Difficulty in obtaining deliveries of structural steel led the engineers of the Hydro-Electric Power Commission to adhere to concrete arch design.

During the construction of the Canal, temporary trestles were generally provided and the construction of the permanent structures was not considered until late in 1920. At this date the situation regarding the supply of structural steel had improved and generally conditions affecting the economic comparison of concrete with steel for the highway bridges had changed. Upon further studies being made, it was decided that the steel spans would be far more economical than concrete arches.

The engineers of the Hydro-Electric Power Commission thereupon prepared plans for steel bridges, providing a width of roadway of 20 feet in each case. These plans were submitted to the Municipalities for their approval. The local authorities, however, would not agree to the proposed change from concrete to steel and a lengthy discussion ensued. A final agreement between the parties was reached and concluded on May 11th, 1922. In the contract entered into on this date, in return for the right to erect steel bridges, the Hydro-Electric Power Commission made the following concessions:-

(a) The width of the roadway on the bridges was increased from 20 to 30 feet.

(b) Certain agreements of the Municipalities regarding damaged roads amounting in value to $7,800.00 were granted.

(c) The Municipalities were given, free of charge, 30,000 tons of rubble stone from the stock pile.

(d) The Commission accepted the Municipal Debenture issue for $90,000.00 in payment for an additional 300,000 tons of rubble stone from the stock pile.

It might be noted in passing that the Municipalities were securing the widest county and township bridges in the Province. On the other hand, the engineers of the Hydro-Electric Power Commission estimate that they have saved about $200,000.00 by the substitution of steel for concrete structures.

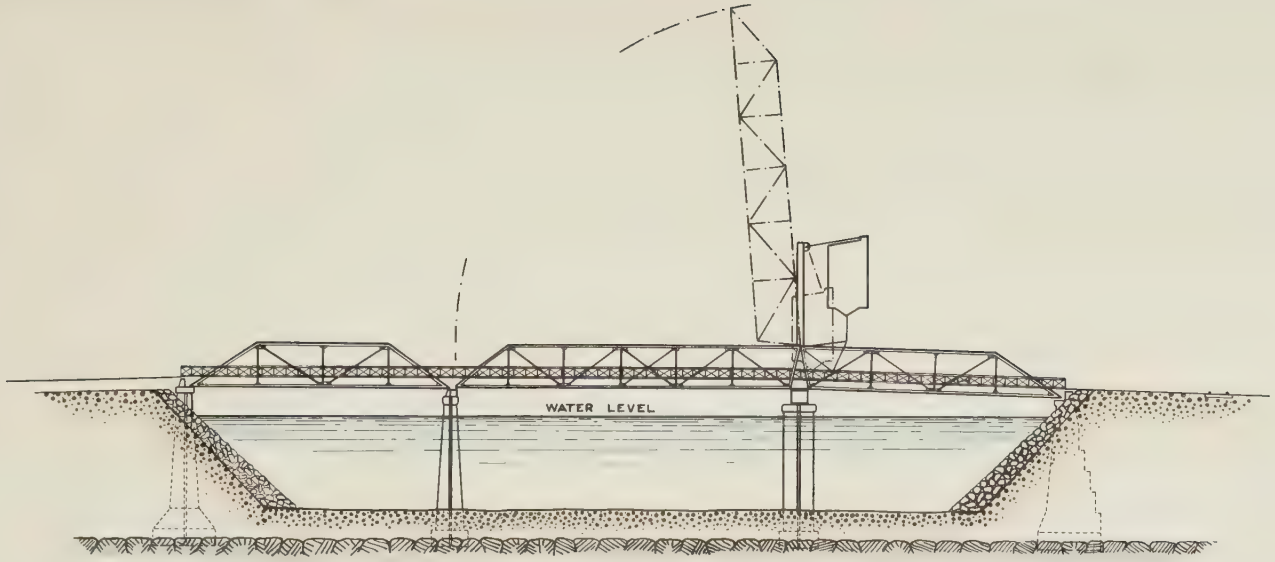
A description of each of the highway bridges with a short history of its construction, together with special negotiations, now follows.

Bridgewater Street Bridge.

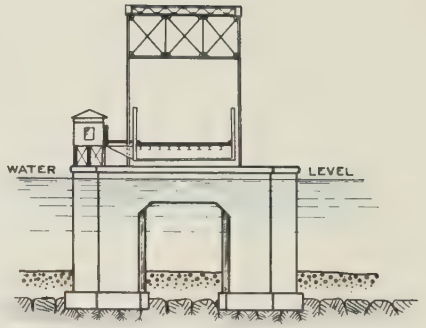
The Bridgewater Street Bridge is located in the Village of Chippawa and carries that part of the Chippawa Provincial Highway, in the Village of Chippawa, known as Bridgewater Street, across the Welland River. The location of the bridge is shown at "A" on the plan on page J-102, and the drawing included as Page J-106 shows the general plan and elevation of the bridge.

The construction of the Bridge was made necessary by the widening and deepening of the Welland River for power purposes, and it replaces an old highway bridge at the same location. The old bridge consisted of a 110-foot steel swing span with a wooden truss approach span at the south end, and was in a very bad state of repair.

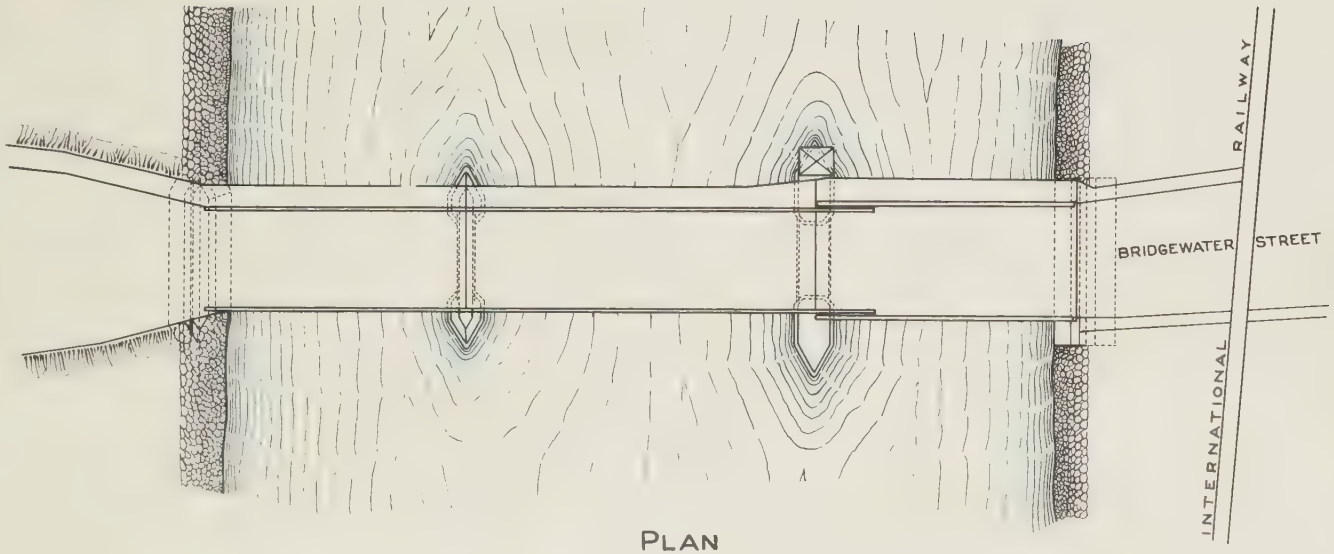
The new bridge is a permanent structure consisting of one 99-foot bascule span of the Strauss trunnion type in the centre, with 75-foot steel pony truss approach spans at each end. The flooring of the bascule span is of wood block, and the approach spans of reinforced concrete slab.



SIDE ELEVATION PARALLEL TO HIGHWAY



CROSS SECTION ON CENTRE LINE OF RIVER



PLAN

Scale of Feet

HYDRO-ELECTRIC INQUIRY COMMISSION

W. D. GREGORY - CHAIRMAN

QUEENSTON-CHIPPAWA POWER DEVELOPMENT

BRIDGEWATER STREET BRIDGE

Toronto, Oct. 12th, 1922. Made by [illegible] Checked by [illegible]

WALTER J. FRANCIS, C.E.,

CONSULTING ENGINEER

(J-106)

The roadway is 24 feet wide between curbs with a 6-foot sidewalk on the south-west side. Provision has been made for the addition of a future sidewalk on the northeast side. The bridge is designed to carry loading class "C" of the Department of Public Highways of Ontario.

The bascule type of bridge was chosen in preference to the swing type on account of the extra cost and the obstruction to channel of the river by the large centre pier and rest piers required for the latter type. The bridge was originally designed for hand operation of the bascule span; but during the summer of 1921 the Department of Railways and Canals of Canada ordered that electric operating equipment be installed. This equipment, consisting of two 30 horse-power motors, was put into operation late in the summer of 1921. Hand operation of the bascule span required one and one-half hours to open and close the bridge.

During the construction the Chippawa Highway was diverted over a temporary trestle, which was built about 300 feet south-westerly from the location of the permanent bridge. This temporary trestle was removed when the permanent bridge was completed and opened to traffic. In order to excavate to solid rock for the north-westerly abutment, it was necessary to support the track of the International Electric Railway on pile bents. Timber caissons were constructed on shore and floated to the location of the piers and abutments in the river. After being seated and sealed the caissons were pumped out, and the concrete piers and abutments constructed within them.

The old swing span highway bridge across the Welland River was operated and maintained by the Department of Railways and Canals of Canada. As widening and deepening of the river necessitated changes to the old bridge, and as

the bridge required repairs, the Department of Railways and Canals was approached by the Hydro-Electric Power Commission with a view to the Department bearing a proportion of the cost of this work. The Department having intimated that they were unwilling to do so, or to maintain the bridge in any better condition, the Hydro-Electric Power Commission endeavoured to have the Niagara Falls Park Commission take over the bridge. A meeting of the interested parties was held on October 16th and 17th, 1917, at which nothing definite was decided.

Changes in the plans of the section of the river to be dredged having been made by the Hydraulic Department of the Hydro-Electric Power Commission, and it being necessary, on this account, to replace the old bridge with a new one, a bascule bridge was decided upon and plans for a bridge of this type to suit the changed conditions were drawn up by the Hydro-Electric Power Commission and submitted to the Department of Railways and Canals for approval in July, 1918. As a condition of approval the Department required the addition to the plans of a retaining wall several hundred feet long on the north bank of the river to protect the ship channel. According to the estimates of the Hydro-Electric Power Commission this wall would have cost about $250,000.00. Negotiations were continued and a temporary arrangement eliminating the proposed wall was verbally agreed to by the Department of Railways and Canals.

The construction of the temporary trestle was commenced on April 29th, 1919, with the dredge "Boone" excavating the river below the bridge site. Upon completion of the temporary structure, the superstructure of the old bridge was removed and the dredge commenced excavating across the site of the

bridge on August 9th, 1919. The material removed from the old bridge was found to be worthless.

In January, 1919, the question of the participation of the Niagara Falls Park Commission in the cost of the bridge was broached and negotiations were carried on until the end of June, 1919, when the Park Commission agreed to pay $15,000 toward the cost of the bridge if the roadway were made 24 feet wide between curbs, instead of 20 feet as designed.

New plans incorporating this 24-foot wide roadway were then drawn up by the Hydro-Electric Power Commission and submitted to the Department of Railways and Canals, who again demanded that the long retaining wall be included. The bridge was then re-designed by introducing an extra pier in order to bring the ship channel near the centre of the river. This plan was approved by the Department of Railways and Canals on September 8th, 1919.

The erection of the caisson for the northerly abutment was commenced on October 14th, 1919, and it was towed to position and sunk on November 15th, 1919. Concreting on the northerly abutment started on December 10th, 1919.

Detail plans and specifications for the steel superstructure were drawn up and ready for tenders by the middle of November, 1919. Tenders were opened on November 28th, 1919, and the contract awarded to The Hamilton Bridge Works Company, Limited. The contract was signed on January 6th, 1920, and called for the completion of the steel work by June 30th, 1920. This was later extended to January 31st, 1921.

Meanwhile, work on the substructure was prosecuted continuously and was completed on June 26th, 1920.

Material was ordered from the mills in Pittsburgh by the contractor on

January 16th, 1920. In February, 1920, the mills refused to guarantee delivery and in April, 1920, they would not promise to commence rolling the structural shapes before July, 1920.

The Hydro-Electric Power Commission were constantly pressing the contractor to commence work, both by letter and by visits of representatives to the shops at Hamilton, and in July, 1920, wrote the contractor that the Commission would hold the Company responsible for any accident due to prolonged use of the temporary trestle and for holding up other work. The contractor applied for extension of the time limit of contract, claiming the cause of the delay to be beyond their control, and after some negotiation the time allowed for completion of the contract was extended to January 31st, 1921.

The shopwork was started in the beginning of November, 1920, and the first car of fabricated steel was shipped from the contractor's works on November 16th, 1920. Erection was commenced on December 1st, 1920. During December the Hydro-Electric Power Commission complained frequently to the contractor of the slow progress of the work. All steel and erecting machinery had been shipped by the end of December, and an extra erector was put on the work and the working force increased on December 31st, 1920.

The bridge was opened for traffic on April 14th, 1921, and the erection of steel and painting completed on May 21st, 1921. Motor operation of the bascule span was installed late in the summer of 1921, and the bridge taken over by the Department of Railways and Canals on November 5th, 1921.

Chippawa Creek Road Bridge.

The Chippawa Creek Road temporary bridge is located at the crossing of

the canal by the Chippawa Creek Township Road near the junction of the Canal proper with the Welland River. The location of the bridge is shown at "D" on key plan on page J-102, and the photograph included as page J-112 gives a view of the bridge, looking north down the Canal.

The bridge is a temporary structure 248 feet long, consisting of a centre span of steel I beams resting on double pile bent piers, with timber bent approach spans on piles at each end. The centre span has a clear opening of 50 feet and is removable to permit dredges and other vessels to pass. The roadway is 24 feet wide and is double planked. The bridge is designed to carry loading class "B" of the Department of Public Highways of Ontario, and it was designed and built by the Hydraulic Department of the Hydro-Electric Power Commission in April, 1921. It is intended to utilize this temporary structure during the life of the timber pile bents, when it will be replaced by a permanent bridge. The type of permanent structure to replace it has not yet been decided upon.

On December 5th, 1919, the Chippawa Creek Road was temporarily diverted to the south of the road allowance to permit the work of excavating the canal through the original road to proceed. The construction of a temporary timber bridge, 80 feet in length, on the original location of the road was commenced on December 23rd, 1919, and it was completed and opened to traffic on January 8th, 1920. This temporary bridge remained in service until April 28th, 1921, when it was removed to allow the dredge "Cyclone" to pass. The road was then diverted about 500 feet to the north of the road allowance in order to allow time for the construction of the present temporary bridge in the rear of the dredge. Work on the present structure was commenced on April 18th,

COPY FOR ENCLOSURE TO Mr. J. Allan Ross.

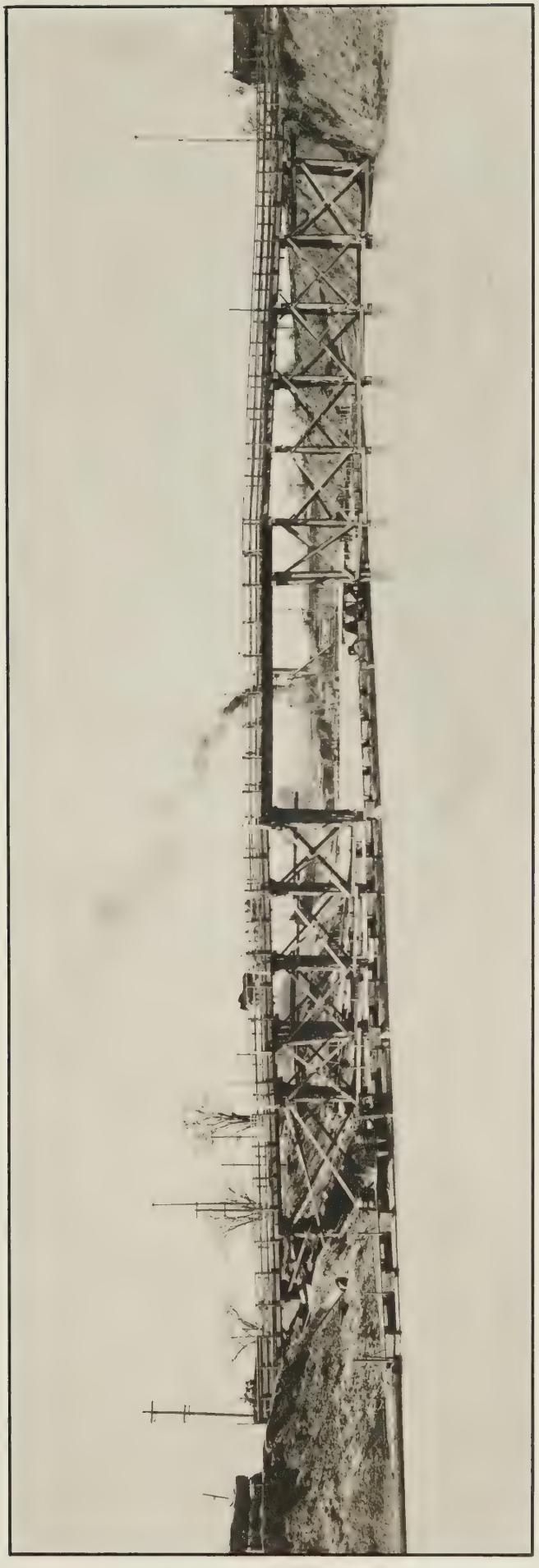
To face page J-112.

Photograph showing

Chippawa Creek Road (Temporary) Bridge

looking north down the Canal.

Taken May 3rd, 1921.



1921, and the bridge was completed and opened for traffic on April 27th, 1921.

Convent Road Bridge.

The Convent Road temporary bridge is located 160 feet north of the original location of the Convent Road at the crossing of the canal, and carries a diversion of this township road across the canal at about Station 95+00. The location of the permanent structure which will eventually replace this temporary bridge is shown at "S" on the plan on page J-102. The photograph on page J-114 shows a view of the bridge looking north, taken during construction of the canal.

The present structure is a temporary timber bridge 188 feet long, consisting of a centre timber through truss span of the Howe type, 80 feet long, supported on double trestle bent piers, with timber post bent approaches at each end. The roadway is double planked and is 14 feet wide. The bridge is designed to carry loading class "B" of the Department of Public Highways of Ontario, and was designed and constructed by the Hydraulic Department of the Hydro-Electric Power Commission.

It is intended to utilize this temporary structure during its life and to then replace it with a permanent bridge of the steel truss type with a reinforced concrete deck, supported on concrete piers and abutments. The permanent bridge will be built on the original location of the road allowance.

On October 29th, 1920, the Convent Road was diverted about 800 feet to the south of the road allowance to permit the work of excavating the canal through the original road to proceed. The construction of the present

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COPY

The present structure is a temporary timber bridge just four feet long, consisting of a centre timber through truss of the Howe type, 50 feet long, supported on double trestle bent piers, with timber post and approaches at each end. The roadway is 20 feet wide and is in good order. The bridge is designed to carry loading since 1924 of the Department of Roads Highways of Ontario, and was designed and constructed by the Ontario Department of Highways-Toronto [illegible].

It is intended to retain this temporary structure during the 1951 and to then replace it with a permanent bridge of the steel truss type with a reinforced [illegible] on [illegible] side for traffic. The permanent bridge will be built on the original location of the road allowance.

The north of the road allowance to permit the work of reconstructing the small [illegible] the original road to proceed. The construction of the present

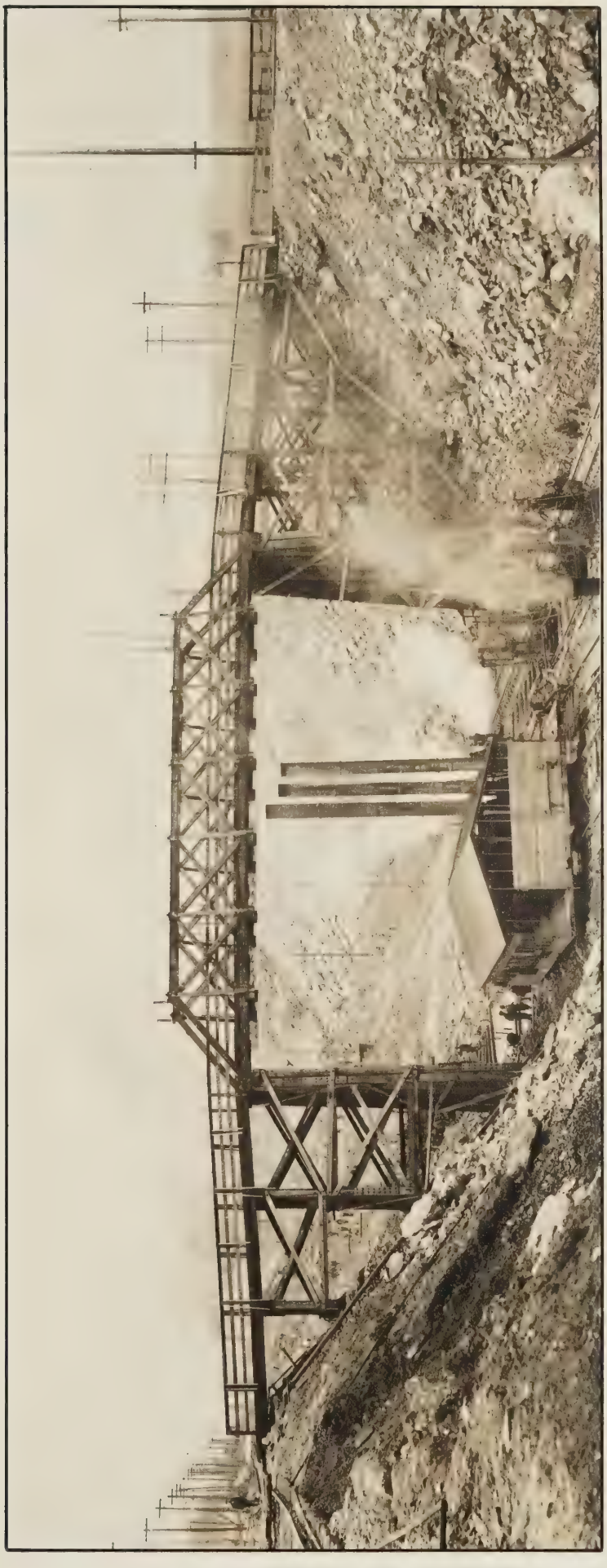
To face page J-114.

Photograph showing

Convent Road (Temporary) Bridge

looking north.

Yukon May 31st, 1921.



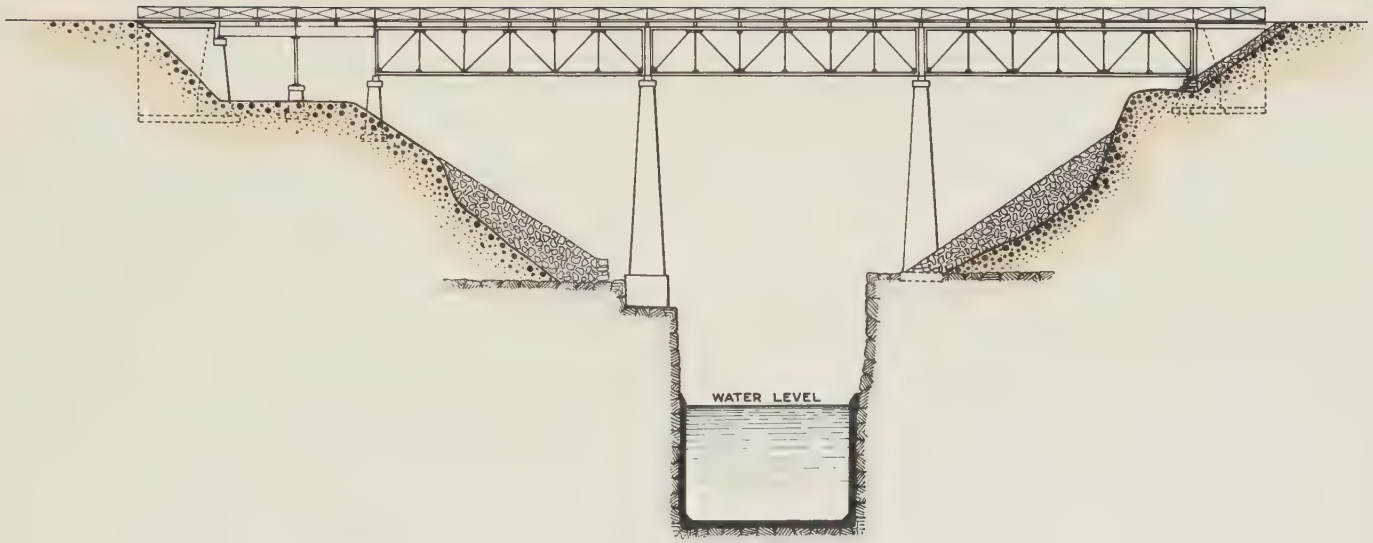
temporary bridge at a point about 160 feet to the north of the road allowance was begun during the week ending April 23rd, 1921, and the bridge was completed and opened for traffic on May 17th, 1921.

Lundys Lane Bridge.

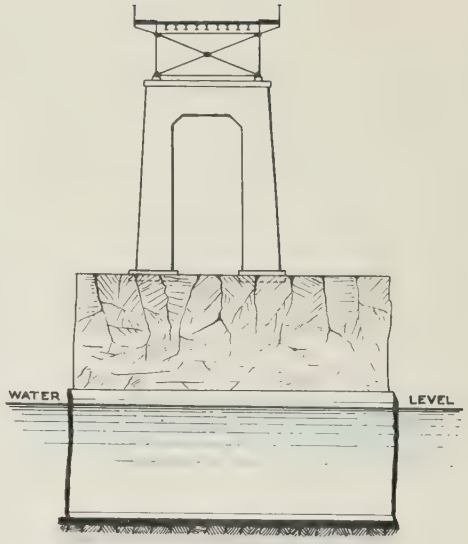
The Lundys Lane Bridge is located at the crossing of the canal by Lundys Lane, a Provincial Highway, at Station 162.00. The location of the bridge is shown at "F" on the plan on page J-102, and the general plan and elevations are shown on the drawing included as page J-116.

The bridge, which is a permanent structure, is approximately 285 feet long, and consists of three steel deck truss spans and two steel deck girder spans, the girder spans being at the west end of the bridge. The piers and abutments are of concrete, the abutments and the two west piers are founded on hard clay loam without piling and the two main piers rest on solid rock. The flooring is of reinforced concrete, the roadway being 34 feet wide between curbs with a sidewalk 6 feet wide on each side. An 8" water main with frost proof covering for the supply of water to the west side of the canal is carried on the bridge. Pending the erection of the bridge the water supply was provided by a temporary pipe line carried across the canal on the Winery Road Bridge. The water main and frost proof covering were supplied and erected by the Hydro-Electric Power Commission. The bridge is designed to carry loading class "C" of the Department of Public Highways of Ontario.

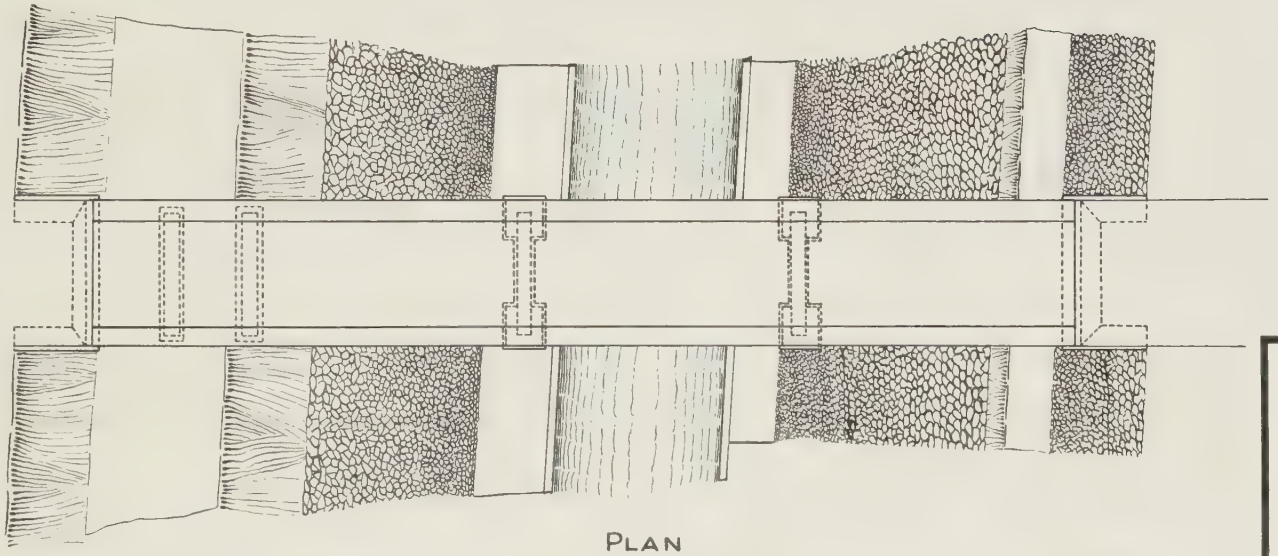
On September 1st, 1919, Lundys Lane was diverted 800 feet to the north



SIDE ELEVATION PARALLEL TO HIGHWAY



CROSS SECTION ON CENTRE LINE OF CANAL



PLAN

Scale of Feet

HYDRO-ELECTRIC INQUIRY COMMISSION

W. D. GREGORY-CHAIRMAN

QUEENSTON-CHIPPAWA POWER DEVELOPMENT

LUNDYS LANE BRIDGE

Toronto, Oct. 12th 1922. Made by W.D. Checked by W.J.

WALTER J. FRANCIS, C.E.,

CONSULTING ENGINEER

(J-116)

of the original road, as a level crossing over the construction railway tracks. In February, 1920, it was necessary to remove the earth overburden at the diversion crossing of the Canal, and Lundys Lane was diverted over the Winery Road Bridge, pending the completion of the permanent structure at the original location of the crossing of the Canal by Lundys Lane.

The structure is now under construction, the piers and abutments having been completed under contract by the firm of Campbell & Lattimore. The erection of the steelwork has been completed by the Canadian Bridge Co., Limited, under contract, and the reinforced concrete floor, with the exception of the sidewalks, was completed on December 5th, 1922. The water main has been installed and tested and work on the frost proof covering for the main is now proceeding.

Winery Road Bridge.

The Winery Road temporary bridge is located 225 feet northerly of the original location of the crossing of the Canal by the Winery Road as shown at "G" on the plan on page J-102. The photograph included as page J-118 shows a view of the bridge looking north down the Canal. The bridge carries a diversion of the township road known as Winery Road and a diversion of Lundys Lane across the Canal.

The present bridge is a temporary structure about 200 feet long, and it was constructed at right angles to the canal centre line. It consists of a central timber truss span of the Pratt type, 88 feet long, supported on timber bent piers with a post bent approach on the west end and a plate

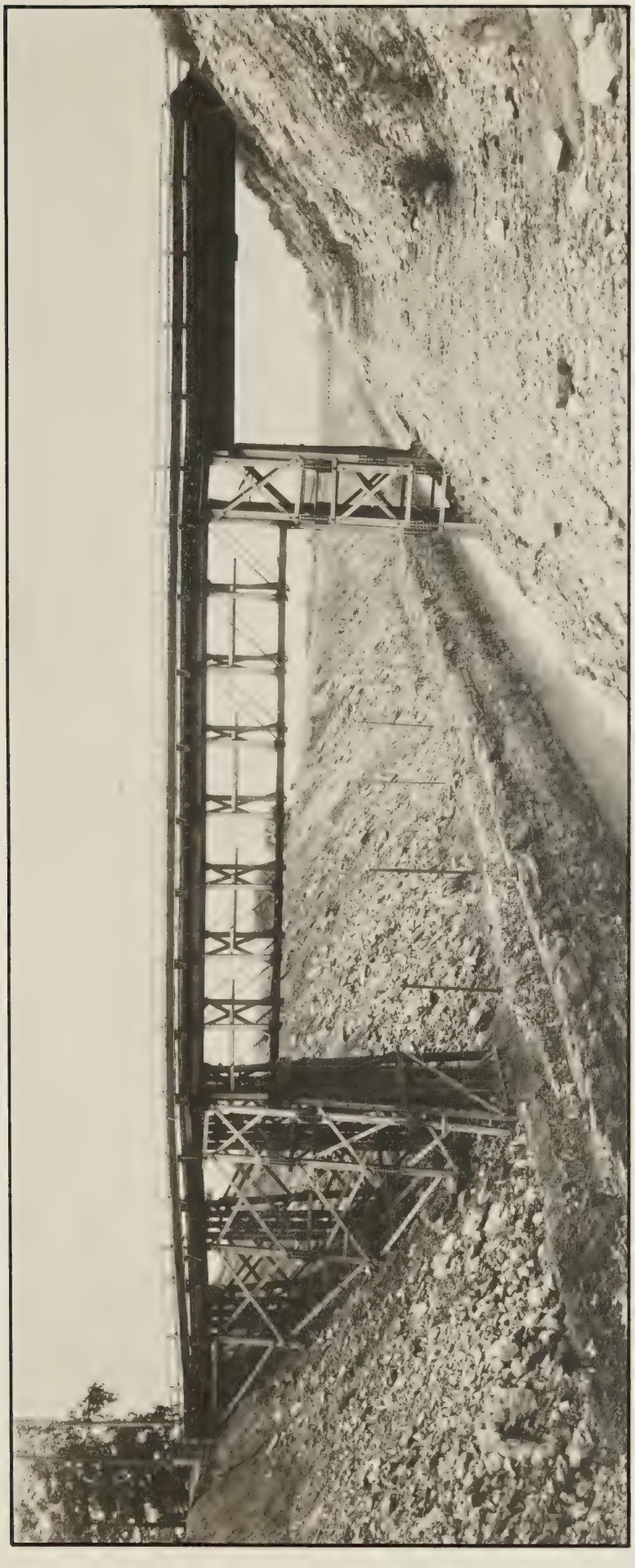
To face page J-113.

Photograph showing

Winery Road (Temporary) Bridge

looking north.

Taken September 15th, 1922.



girder span on the east end. The roadway is double planked and is 16 feet wide. The bridge is designed to carry loading class "C" of the Department of Public Highways of Ontario, and it was designed and built by the Hydraulic Department of the Hydro-Electric Power Commission.

It is intended to utilize this temporary structure during its life and then to replace it with a permanent steel truss bridge on concrete piers and abutments, with a reinforced concrete deck, which will be built on the original location of the road.

Victoria Street Bridge.

The Victoria Street temporary bridge is located about 120 feet southerly from the original location of Victoria Street, a Township Road, and carries diversions of this street and the Portage Road across the canal at about Station 232+00. The location of the permanent structure which is intended to eventually replace this temporary bridge is shown at "H" on the plan on page J-102. The photograph on page J-120, taken during excavation of the canal, shows the south side of this temporary bridge.

The present bridge is a temporary structure about 265 feet long, consisting of a central timber deck truss span of the Howe type with frame and pile trestle approaches at each end. The roadway is double planked and is 16 feet wide. The bridge is designed to carry loading class "B" of the Department of Public Highways of Ontario, and it was designed and built by the Hydraulic Department of the Hydro-Electric Power Commission. The erection was commenced during the week ending November 1st, 1919, and the

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To face page J-120.

Photograph showing

COPY

Victoria Street (Temporary) Bridge

Taken December 2nd, 1920.

bridge was opened for traffic on November 18th, 1919.

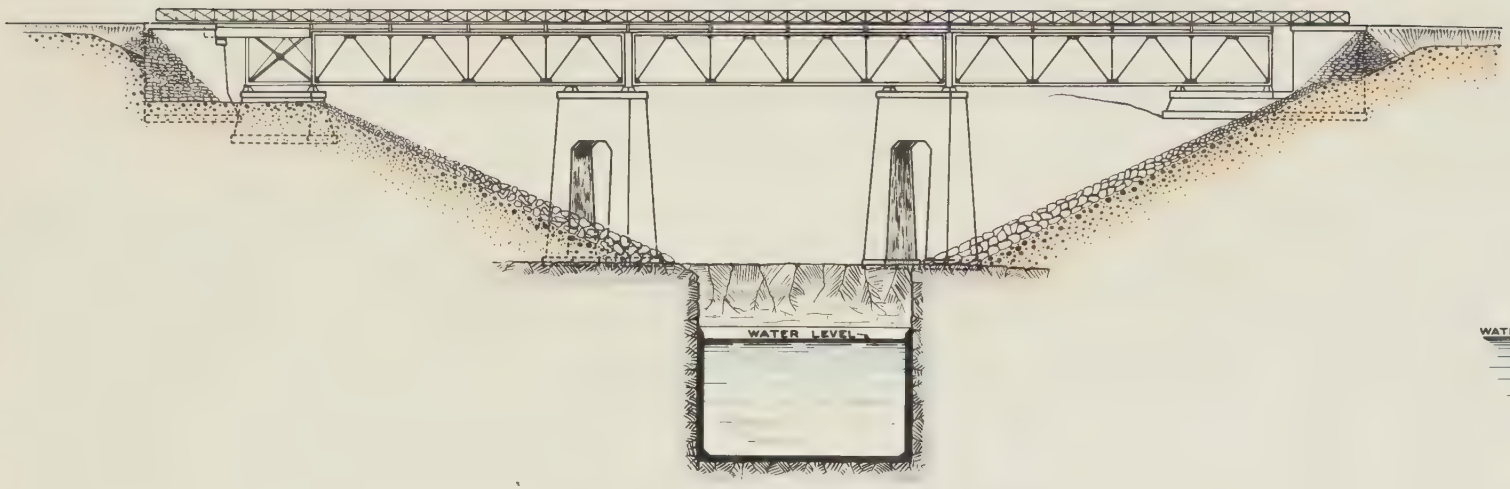
It is intended to utilize this temporary structure during its life and then to replace it with a permanent steel truss bridge on concrete piers and abutments, which will be built on the original location of Victoria Street.

Portage Road Bridge.

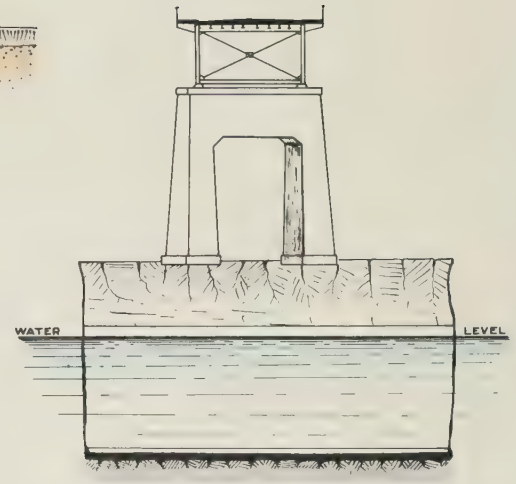
The Portage Road bridge is located at the crossing of the canal by the Portage Road, a County Highway, at about Station 249+00. The location of the bridge is shown at "I" on the plan on page J-102, and the general plan and elevation are shown on the drawing included as page J-122.

The bridge, which is a permanent structure, is about 319 feet long and consists of three steel truss deck spans and one steel girder deck span, with a reinforced concrete floor. The piers and abutments are of concrete, the northerly abutment and northerly pier being founded on hard clay loam without piling, while the remainder of the piers and the southerly abutment rest on solid rock. The roadway is 30 feet wide between the curbs, with a sidewalk, 6 feet wide, on each side. The centre line of the bridge makes an angle with the centre line of the canal of 53 degrees 8 minutes. It is designed to carry loading class "B" of the Department of Public Highways of Ontario.

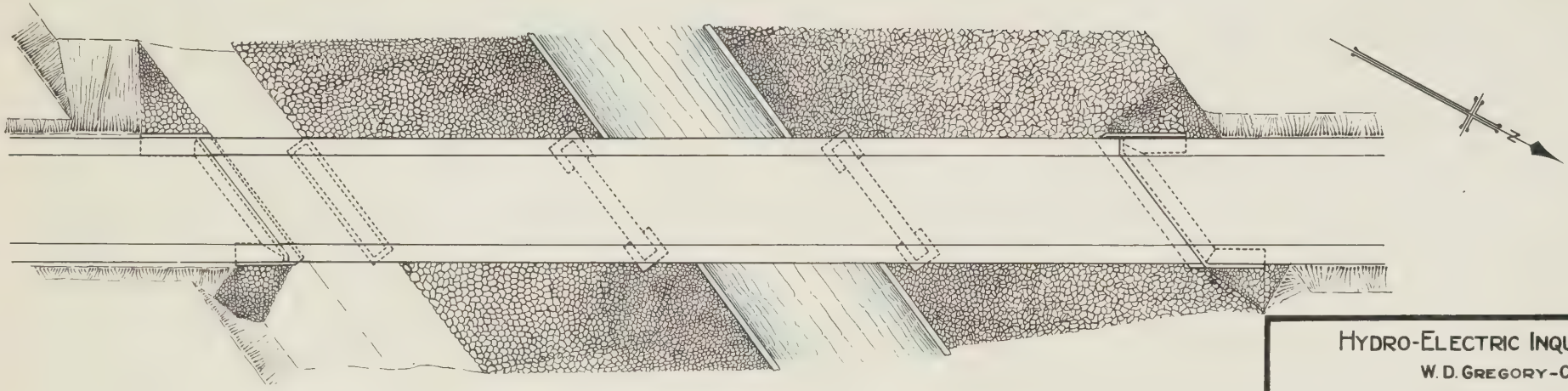
The structure is now under construction, the piers and abutments having been completed under contract by the firm of Campbell & Lattimore. The erection of the steel superstructure is proceeding and is about one-half completed. The steel work is being done under contract by the Canadian Bridge Co. Limited. The contract date for the completion of the steel work was



SIDE ELEVATION PARALLEL TO HIGHWAY



CROSS SECTION ON CENTRE LINE OF CANAL



PLAN

20 15 12 8 4 0 10 20 30 40 50 60 70 80 90 100
18 14 10 6 2

Scale of Feet

HYDRO-ELECTRIC INQUIRY COMMISSION

W. D. GREGORY-CHAIRMAN

QUEENSTON-CHIPPAWA POWER DEVELOPMENT

PORTAGE ROAD BRIDGE

Toronto, Oct. 12th., 1922. Made by E.M.D. Checked by W.J.F.

WALTER J. FRANCIS, C.E.,

CONSULTING ENGINEER

(J-122)

September 15th, 1922.

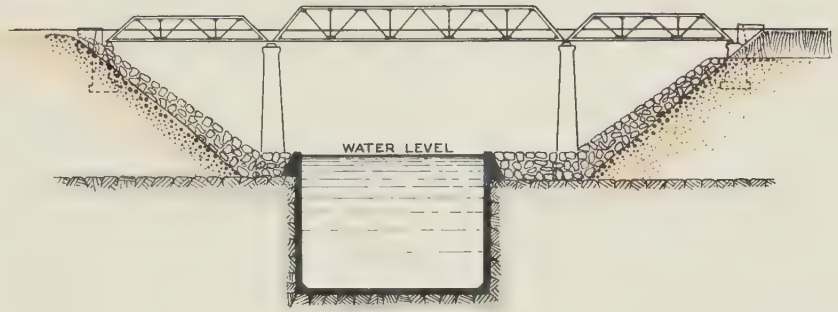
No temporary structure was built for this crossing, the traffic being diverted over the Victoria Street temporary bridge.

Thorold Road Bridge.

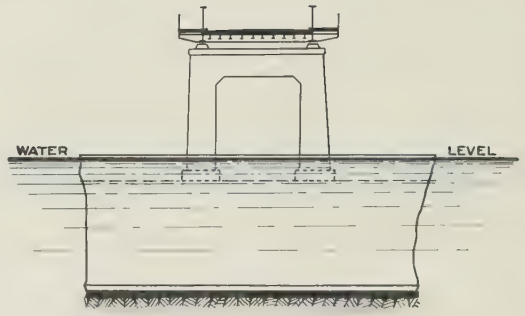
The Thorold Road Bridge is located at the crossing of the canal by the Thorold Road, a Provincial Highway, at about Station 289+00. The location of the bridge is shown at "K" on the plan on page J-102, and the general plan and elevations of the structure are shown on the drawing included as page J-124.

The bridge, which is a permenent structure, is about 181 feet long, consisting of one steel pony truss central span 80 feet long with steel pony truss spans 48 feet long at each end. The floor is of reinforced concrete. The piers and abutments are of concrete, the piers being founded on solid rock and the abutments resting on hard sand. The roadway is 30 feet wide between the curbs, with a sidewalk 6 feet wide on each side. The bridge is designed to carry loading class "C" of the Department of Public Highways of Ontario.

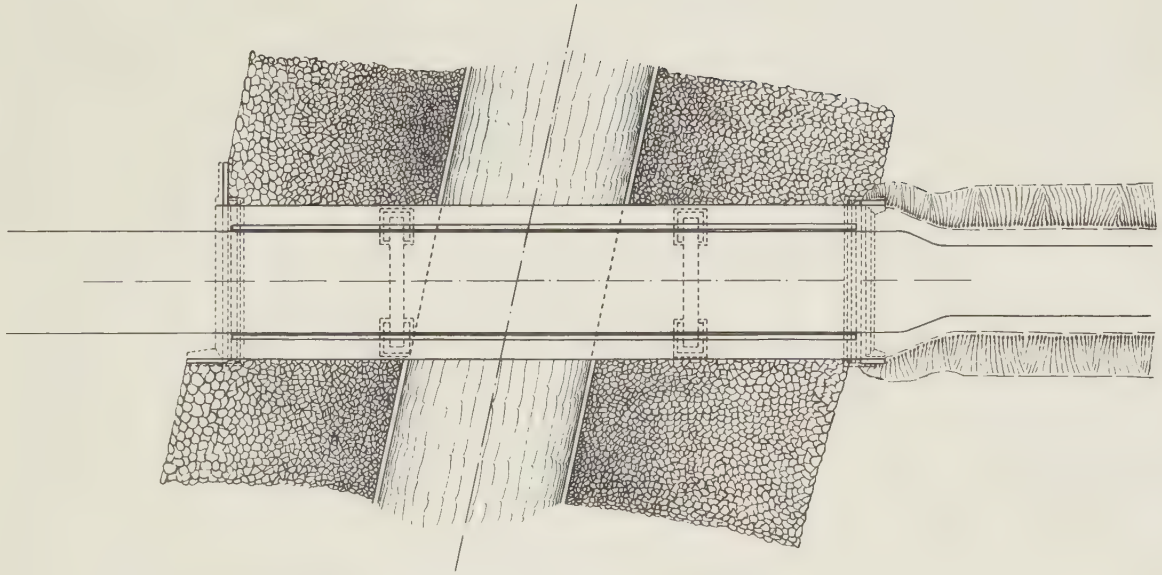
The structure is now under construction, the piers and abutments having been completed under contract by the firm of Campbell & Lattimore, who are now engaged in backfilling at the abutments. The fabrication of the steelwork for the superstructure has been completed, but the steel has not as yet been shipped from the contractor's works. The superstructure is being made and erected under contract by the Canadian Bridge Co. Limited. The bridge



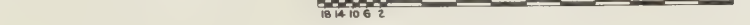
SIDE ELEVATION PARALLEL TO HIGHWAY



CROSS SECTION ON CENTRE LINE OF CANAL



PLAN



Scale of Feet

HYDRO-ELECTRIC INQUIRY COMMISSION

W. D. GREGORY - CHAIRMAN

QUEENSTON-CHIPPAWA POWER DEVELOPMENT

THOROLD ROAD BRIDGE

Toronto, Oct. 12th., 1922. Made by W.T.P. Checked by W.J.F.

WALTER J. FRANCIS, C.E.,

CONSULTING ENGINEER

(J-124)

is built at right angles to the centre line of the Canal and it will carry a diversion of Stanley Street as well as the Thorold Road. No bridge is to be built at the original Stanley Street crossing.

A temporary highway bridge about 243 feet long was built about 600 feet north of the permanent crossing of the Thorold Road. This temporary structure carries diversions of the Thorold Road and Stanley Street across the canal, pending the completion of the permanent bridge on the original location of Thorold Road. This temporary structure consists of a central steel truss deck span over the canal, a steel plate girder span at the east end, and a steel through truss span at the west end, supported on pile and post bent piers. The approaches are of substantial earth fill. The roadway is double planked and is 16 feet wide. The structural steel used was second-hand material purchased chiefly from the Guelph & Goderich Railway. The temporary bridge was originally designed for class "C" loading of the Department of Public Highways of Ontario, but on authority of the Ontario Railway and Municipal Board this loading was reduced to class "B". This temporary structure was designed and built by the Hydraulic Department of the Hydro-Electric Power Commission. Work on the temporary structure was commenced during the week ending January 25th, 1919, and the bridge was opened to traffic on April 5th, 1919. It will be dismantled on completion of the permanent bridge.

Railway Bridges.

The following table gives a list of the railway bridges over the Welland

River and the Canal which were constructed by the Hydro-Electric Power Commission, with the location, type and present condition of each. The stations referred to under Location are the Canal centre line chainages. The railway bridges are all permanent structures.

Table of Railway Bridges.

Reference Letter on Key Plan	Bridge	Location	Type	Present Condition
B.	Michigan Central Railroad	Chippawa	Steel Swing Span	Completed.
C.	Michigan Central Railroad	Montrose	Steel Girder Span	Completed.
J.	Niagara, St. Catharines & Toronto Railway	Sta.273+00	Concrete Arch	Completed.
L.	Wabash Railroad	Sta.310+00	Concrete Arch	Completed.
M.	Grand Trunk Railway and Michigan Central Railroad	Sta.334+00	Concrete Arch	Completed.

Negotiations with the railway companies concerned, regarding the railway crossings of the Canal were commenced by the Hydro-Electric Power Commission in the Fall of 1916. An agreement was signed with the Michigan Central Railroad for the bridges at Chippawa and Montrose and an agreement for the combined Grand Trunk Railway and Michigan Central Railroad bridge was signed by the parties concerned on August 4th, 1917. The agreement with the Grand Trunk Railway covering the Grand Trunk Railway (Wabash) bridge was also signed on August 4th, 1917.

No agreement was made with the Niagara, St. Catharines & Toronto Railway

with regard to their bridge. The negotiations were carried on by letter and the letters formed the instructions and authority for the work.

During construction of the railway bridges, temporary diversions of the tracks were made and temporary trestles to carry these diversions were constructed for each bridge, with the exception of the Niagara, St. Catharines & Toronto Railway, which was diverted on the ground surface, as the Canal had not then been excavated at this point. These temporary diversions have now been dismantled.

A description of each of the railway bridges with a short history of its construction, together with special negotiations, now follows.

COPY

Michigan Central Railroad Bridge at Chippawa.

The Michigan Central Railroad Bridge at Chippawa is located at the crossing of the Welland River by the Michigan Central Railroad near the Village of Chippawa and carries the Niagara-on-the-Lake branch of this railroad across the Welland River. The location of the bridge is shown at "B" on the plan on page J-102, and a general plan and elevations are given on drawing included as page J-128.

The construction of the bridge was made necessary by the widening and deepening of the Welland River for power purposes, and it replaces an old steel swing span railroad bridge at the same location. The old bridge consisted of one steel pony truss swing span with a timber approach at the easterly end.

The new bridge is a permanent structure about 303 feet long, consisting of one steel pony truss swing span 150 feet long, which will be manually operated, and two steel half-through girder spans at the easterly end. The swing span from the old bridge was utilized for the central span of the new structure, and the steel girders for the approach spans were second-hand material purchased from the Buffalo & Susquehanna Railroad and were remodelled on the ground with the addition of 74,400 pounds of new steel. Open floor construction was used on all the spans. The main piers and the abutments are of concrete founded on solid rock, the guard and the rest piers for the swing span are of timber, stone filled, crib construction resting on solid rock, the rest piers being capped with concrete.

The Michigan Central Railroad originally demanded that the bridge be designed to carry Cooper's E-70 loading; but the final agreement and design provided for Cooper's E-45 loading with some modifications.

The agreement between the Michigan Central Railroad and the Hydro-Electric Power Commission covered the diversion of traffic during construction with provisions as to responsibility for accidents. The traffic on the railroad was not to be interrupted and the work was to be done under the supervision and to the satisfaction of the Michigan Central Railroad. The increased value of the new bridge was computed by deducting the present capitalized value of the sinking fund and maintenance charges on the extra span, necessitated by the widening of the river, from the total increased value of the bridge, due to the new piers and abutments and the using of steel in lieu of wood on the approach spans. This value was found to be $4,879.37, and the agreement provided that this sum be paid to the Hydro-

The new bridge is a permanent structure about [illegible] feet long, [illegible] [illegible] [illegible], and the [illegible] [illegible]. The main span from the old bridge was [illegible] for the central [illegible] of the new structure, and the steel girders for the approach spans were [illegible] [illegible] from the [illegible] [illegible] [illegible] construction was used on all the spans. The main piers and the abutments [illegible] of concrete [illegible] [illegible] the [illegible]

COPY

[illegible]

The [illegible] Electric Power Commission covered the [illegible] of [illegible] during [illegible] [illegible] and in the [illegible] of the [illegible]. The estimated value of the new bridge was computed by [illegible] value of the existing [illegible] and [illegible], [illegible] by the [illegible], [illegible] value of the bridge, [illegible] the [illegible] piers and [illegible] and the value of [illegible] spans. [illegible] value was found to be [illegible], [illegible] provided that this sum be paid to the [illegible]

Electric Power Commission by the Michigan Central Railroad, six months after the bridge had been accepted by the Board of Railway Commissioners for Canada, and after that date all maintenance would be assumed by the Michigan Central Railroad.

A timber diversion trestle bridge about 388 feet long, utilizing the steel swing span from the old bridge, was constructed across the river 38 feet southerly from the location of the permanent bridge. Work on this diversion trestle commenced on May 31st, 1919, and the steel swing span was moved over from the old bridge to the temporary structure on August 2nd, 1919, without interruption to traffic. As the foundations of the piers of the old bridge were above the proposed bed of the Welland River, as improved, it was necessary to remove them in order to excavate to solid rock. The proximity of the diversion trestle to the permanent bridge made it necessary to excavate for the foundations of the new piers within sheet pile cofferdams. The Michigan Central Railroad submarine cable across the river was replaced by overhead wires during construction.

The excavation work and the removal of the old piers was commenced during the week ending August 16th, 1919, and the driving of the sheet piling for the cofferdams during the week ending September 27th, 1919. The concrete construction of the permanent piers was commenced on November 11th, 1919, and the entire substructure was completed on October 6th, 1920.

The erection of the steel superstructure on the shore spans, was commenced on September 11th, 1920, and the central swing span was moved over from the diversion trestle to its final position in the new bridge on December 21st, 1920, permitting traffic to cross the new bridge on the same day.

The structure was completed, with the exception of painting and the construction of the two guard piers and the two rest piers for the swing span, on January 10th, 1921. The guard and rest piers are not as yet completed.

Permission to operate over the bridge has been granted by the Board of Railway Commissioners for Canada.

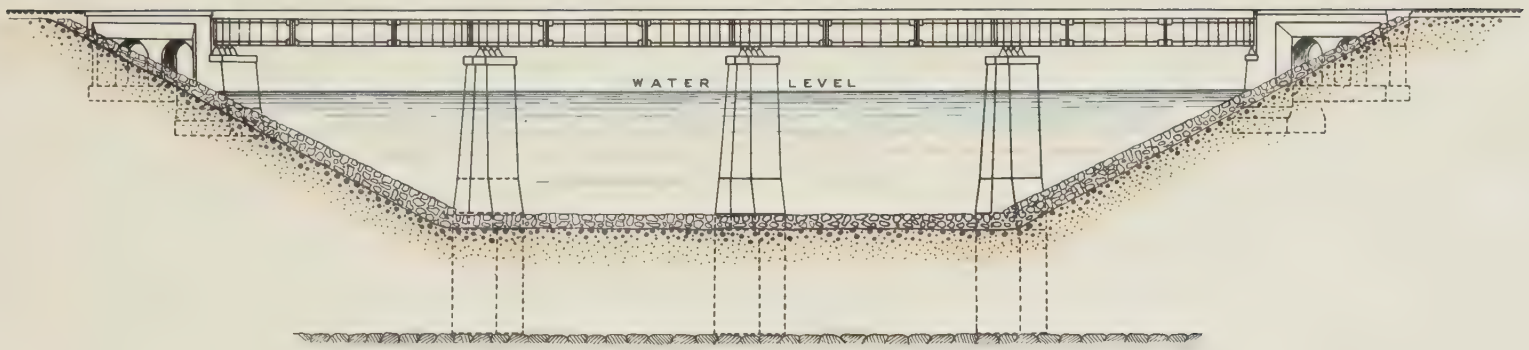
Michigan Central Railroad Bridge at Montrose.

The Michigan Central Railroad Bridge at Montrose is located at the crossing of the Canal by the double track main line of the Michigan Central Railroad at about Station 12.00, near the junction of the Canal proper with the Welland River. The location of the bridge is shown at "G" on the plan on page J-132, and the general plan and elevations are given on drawing included as page J-132.

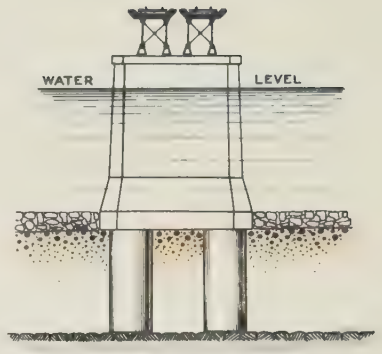
The bridge is a permanent structure about 374 feet long overall, consisting of four steel twin girder spans each 75 feet long, with a reinforced concrete deck supporting rock ballast. The piers and abutments are of reinforced concrete, each of the piers being founded on two twelve-foot diameter steel cylinders sunk to solid rock and filled with concrete, while the abutments rest on pile foundations.

The centre line of the bridge makes an angle with the centre line of the Canal of 76 degrees 26 minutes and 30 seconds, and carries the tracks on a grade of 0.253 per cent. rising from west to east.

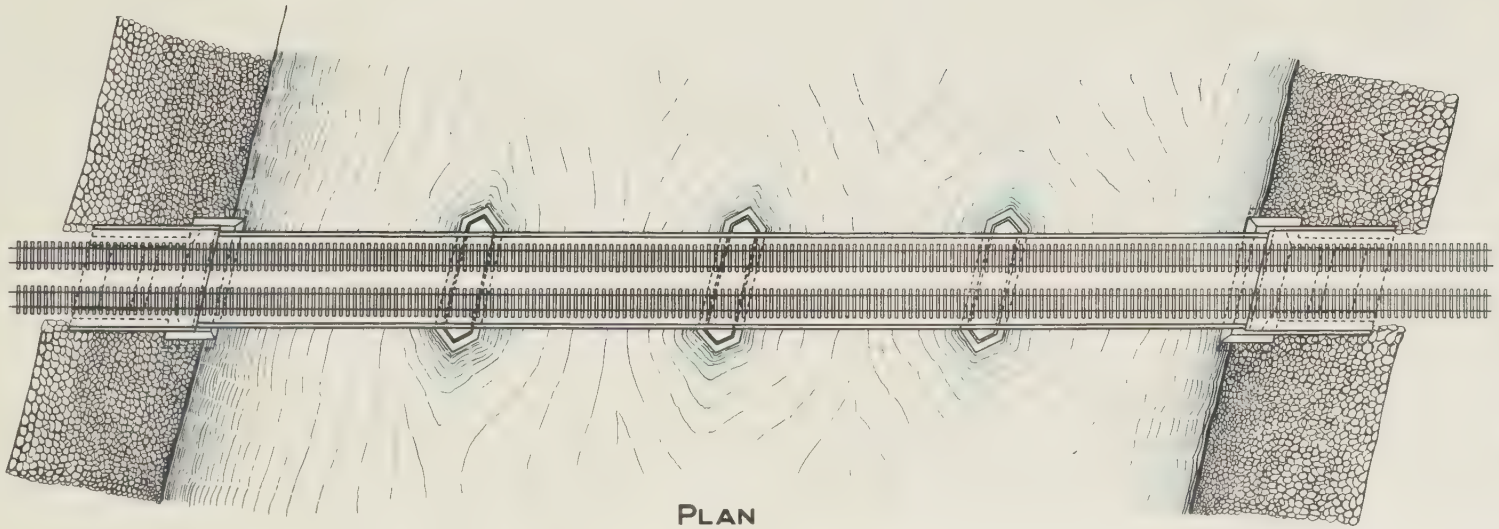
Since the construction of the Power Canal by the Hydro-Electric Power



SIDE ELEVATION PARALLEL TO RAILWAY.



CROSS SECTION ON CENTRE LINE OF RIVER



PLAN

20 16 12 8 4 0 10 20 30 40 50 60 70 80 90 100
18 14 10 6 2
Scale of Feet

HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY-CHAIRMAN
QUEENSTON-CHIPPAWA POWER DEVELOPMENT

MICHIGAN CENTRAL RAILROAD BRIDGE AT MONTROSE

Toronto, Oct. 12th., 1922. Made by [illegible] Checked by [illegible]

WALTER J. FRANCIS, C.E.,
CONSULTING ENGINEER

(J-132)

Commission created the necessity for a bridge at this point, the Michigan Central Railroad was in a position to demand that the bridge conform to the highest type of design. At meetings held between the representatives of the Michigan Central Railroad and the Hydro-Electric Power Commission it was agreed that the bridge be designed with a reinforced concrete deck to carry the rock ballast, the loading condition to be Cooper's E-70, which is extra heavy, and that the total cost and maintenance of the structure be borne by the Hydro-Electric Power Commission. The question of providing for the future extension of the bridge to accomodate four tracks was discussed, the Railroad desiring that the Commission construct the concrete substructure so as to provide for such future extension. This was not agreed upon, and the present substructure provides for the present two-track line only.

An unsuccessful endeavour was made by the Hydro-Electric Power Commission to obtain second-hand steel girders sufficiently strong to carry Cooper's E-70 loading.

On March 16th, 1921, the Board of Railway Commissioners for Canada issued an order approving the design and construction as agreed upon by the Michigan Central Railroad and the Hydro-Electric Power Commission.

A double timber pile bent diversion trestle about 230 feet long was constructed about 80 feet southerly from the permanent bridge site to carry traffic on two tracks during construction of the permanent structure. It was impossible to locate this trestle at a greater distance from the bridge location owing to the presence of the Michigan Central Railroad swing span bridge over the Welland River, and the proximity of the piling of this trestle to the construction work was a serious factor during the construction of the pier foundations

for the permanent bridge.

The construction work on the diversion trestle commenced on February 14th, 1920, and the traffic on the east-bound track was diverted over the trestle on August 5th, 1920. The traffic on the west-bound track was diverted on August 16th, 1920.

The original design for the foundations of the piers in the permanent structure called for pile footings, the design being based on the results of several well-drill borings at the site of the bridge. The driving of the piles was commenced but it was found that the material encountered below the Canal bed level was such that the piles could not be driven satisfactorily. The design of the foundations of the piers was then changed to steel cylindrical caissons to be sunk below the Canal bed level and filled with concrete. These steel caissons are twelve feet in diameter and about 40 feet long, two cylinders being used under each pier. The Canal prism not having been removed when work on the bridge was started, the excavation for the piers was taken down to the approximate bottom of the Canal in timber pile cofferdams, and the steel caissons sunk below this excavation, to rock. The porous water-bearing nature of the lower strata encountered in sinking the cylinders caused considerable difficulty and delay, and pumping out the water and sealing the bottoms of the cylinders was a serious item in the construction. With the completion of the filling of the caissons with concrete the balance of the work was carried out without serious difficulty.

The work on the excavation of the old railroad bed and the pile driving for the pier cofferdams was commenced during the week ending January 22nd, 1921, followed by the driving of the pile foundations for the abutments.

Excavation in the cofferdams was started during the week ending February 19th, 1921.

The first two of the steel cylindrical caissons were placed in position during the week ending July 16th, 1921, and sinking commenced. Serious trouble due to the extreme pressures of water encountered delayed the work considerably. The cylinders were partially sealed on October 5th, 1921, but the trouble was only entirely overcome by November 25th, 1921, when filling the caissons with concrete was begun.

The concrete work on the piers above the caisson foundations was started during the week ending January 14th, 1922, and all the piers and abutments were completed on March 25th, 1922. The erection of the steel superstructure commenced on April 18th, 1922, and was completed on May 19th, 1922. The construction of the concrete deck, water-proofing, ballasting, tracklaying and painting were completed on July 31st, 1922, and the bridge was under full operation by the Michigan Central Railroad on August 1st, 1922.

The substructure and the reinforced concrete deck were built by the Hydro-Electric Power Commission, three of the six steel cylinders being supplied under contract by the Hamilton Bridge Works Co. Limited, and three under contract by the Dominion Bridge Co. Limited. The superstructure steelwork was made and erected by The Canadian Bridge Co. Limited, under contract, and the waterproofing was contracted for by The Carmichael Waterproofing Company.

A contract was also let to the Hamilton Bridge Works Co. Limited, for a 80-foot steel girder span for E-70 loading. This was delivered, but, owing to subsequent changes in the design of the bridge, was not used.

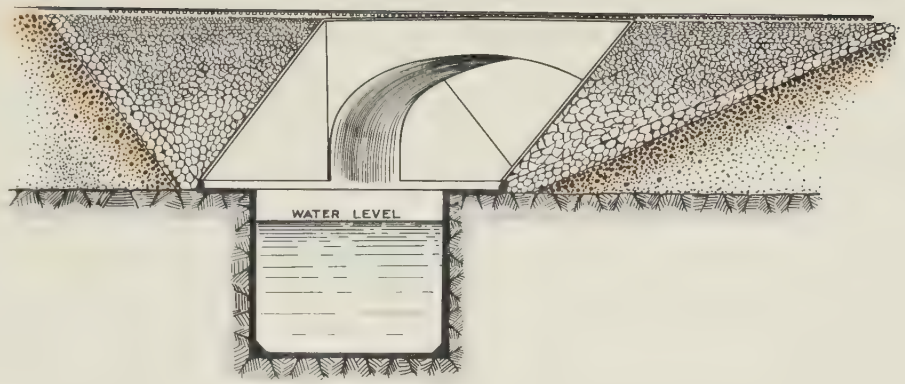
Niagara, St. Catharines & Toronto Railway Bridge.

The Niagara, St. Catharines & Toronto (Electric) Railway Bridge is located at the crossing of the Canal by the Niagara, St. Catharines & Toronto (Electric) Railway at about station 273+00. The location of this bridge is shown at "J" on the plan on page J-102, and a general plan and elevations are given on the drawing on page J-137.

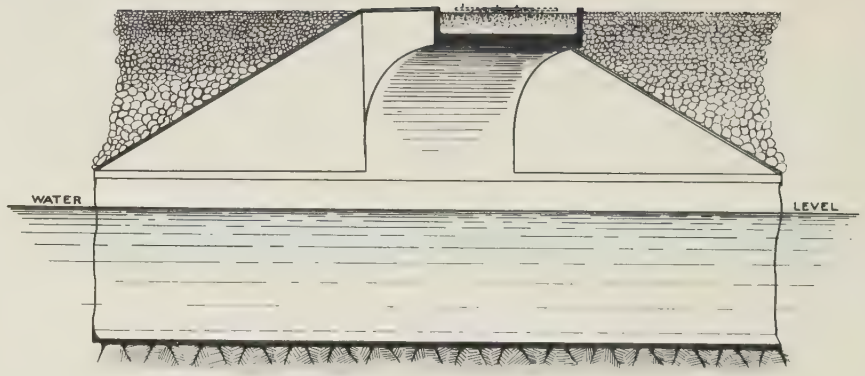
The construction of this bridge was made necessary by the construction of the Power Canal.

The bridge is a permanent structure and consists of a reinforced concrete earth-filled arch of 86-foot span resting on concrete gravity type abutments with wing walls of plain concrete. The abutments are founded on solid rock. The arch rises at the centre 25 feet above the "springing line", or junction of the arch with the abutments, and the thickness of the arch ring at the "crown" or centre of the arch, is four feet. The walls over the arch ring on each side of the bridge, technically known as "spandrel walls", are 10 feet high from the arch crown to the coping of the walls, and the bridge is filled with earth on top of the arch ring between these walls. The spandrel walls are "counterforted" - that is, projections extending from the inside of the walls at intervals across the bridge are tied into the arch ring by reinforcement bars to strengthen the walls. Expansion joints are provided at proper intervals. The bridge is 37 feet 8½ inches wide, and the height of the abutments from the rock foundation to the springing line is 12 feet 6 inches.

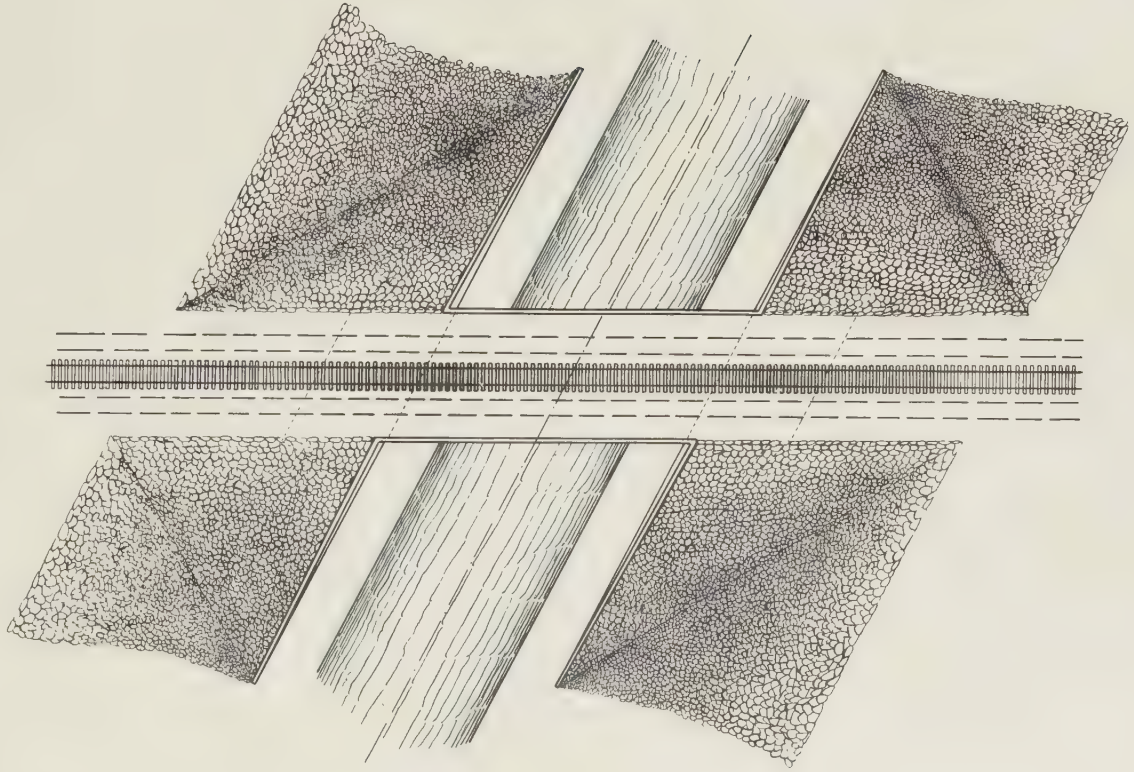
A temporary trestle approach to the arch at the west end, of two steel



SIDE ELEVATION PARALLEL TO RAILWAY



CROSS SECTION ON CENTRE LINE OF CANAL



PLAN

Scale of Feet

HYDRO-ELECTRIC INQUIRY COMMISSION

W. D. GREGORY-CHAIRMAN

QUEENSTON-CHIPPAWA POWER DEVELOPMENT

NIAGARA, ST. CATHARINES & TORONTO RAILWAY BRIDGE

Toronto, Oct. 12th, 1922. Made by [illegible] Checked by [illegible]

WALTER J. FRANCIS, C.E.,

CONSULTING ENGINEER

(J-137)

girder spans each 21 feet long, supported on pile bent piers, carries the electric railway tracks over the double track construction railway. No decision has yet been made as to the replacement of this temporary approach on dismantlement of the construction railway.

The bridge is designed to carry Cooper's E-70 loading, which is standard for the main line of the Grand Trunk Railway. The Hydro-Electric Power Commission engineers state that this design was insisted upon on account of the Canadian National Railway's interest in the Niagara, St. Catharines & Toronto Railway as a future link in the projected Canadian National line through the Niagara Peninsula. The width of 37 feet 8½ inches was demanded by the Niagara, St. Catharines & Toronto Railway in order to provide for two tracks with a central trolley suspension pole line.

The centre line of the bridge makes an angle with the centre line of the Canal of 62 degrees 20 minutes.

The use of the usual "U" wall type of abutment for the arch was found to be uneconomical in this case, as the excavation for the "U" walls at the back of the abutments would have required an excavation about 75 feet long and 50 feet deep at each abutment.

During the construction of the permanent structure the tracks of the Niagara, St. Catharines & Toronto Railway were diverted on a fill on the ground surface, no temporary trestle being required as the Canal was not then excavated at this point. This diversion was constructed between July and September, 1917, and was removed on completion of the bridge.

As the excavation of the Canal at the bridge site had not been made when the work commenced, the bridge was built below the ground level inside bulkheads

of Lackawanna sheet steel piling, the excavations to rock for the foundations of the abutments being about 50 feet deep. The material encountered in driving the steel sheet piling was clay and sand with boulders and coarse sand near the bottom. Driving was very hard and the water bearing stratum near the bottom necessitated heavy pumping throughout the construction work. The boulders encountered also caused distortion of the piling during driving, and this resulted later in expensive slips.

The excavation on the west abutment started on December 5th, 1917, and the concreting on April 25th, 1918. The east abutment was constructed at the same time, each operation being performed on the completion of the same operation on the west abutment. The concreting of the arch ring and spandrel walls followed on completion of the abutments and was completed on October 29th, 1918. The arch ring was concreted in narrow strips of about 6 feet in width, this method being insisted upon by the Niagara, St. Catharines & Toronto Railway's inspector. The earth filling over the arch ring was done by a clam-shell derrick with train-hauled material. A portion of the wing walls was built in the fall of 1921, the balance now being constructed under contract by the firm of Campbell & Lattimore. There are about 150 cubic yards of concrete left to complete at the date of this writing.

When the Canal prism was excavated after the construction of the arch, there was a slight rock slip which resulted in the formation of cracks in the abutments. According to the Hydro-Electric Power Commission engineers, these cracks do not indicate any injury to the structural strength of the bridge.

No written agreement was made with the Niagara, St. Catharines & Toronto Railway, but the Railway Company approved the plans, kept an inspector on the

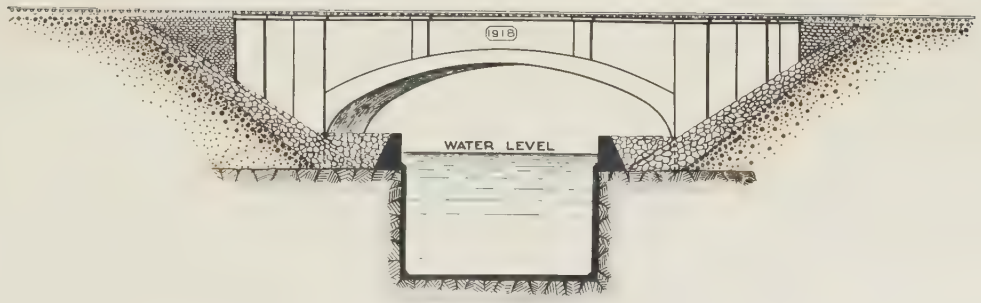
work, and by the interchange of letters with the Hydro-Electric Power Commission adjusted matters of design such as the loading factor required and the roadway width.

Wabash Railroad Bridge.

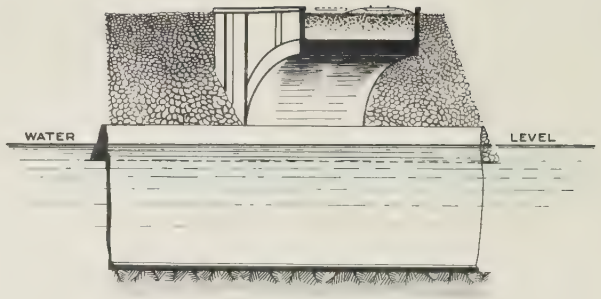
The Wabash Railroad bridge is located at the crossing of the Canal by the Wabash division of the Grand Trunk Railway, District No. 19, at about station 310+00. The location of the bridge is shown at "L" on the plan on page J-102, and the general plan and elevations are shown on the drawing included as page J-141.

The bridge is a permanent structure and consists of a reinforced concrete earth-filled arch of 100 feet span resting on concrete "U" type gravity abutments, founded on solid rock. The arch is of similar type to that of the Niagara, St. Catharines & Toronto Railway bridge. The arch rises at the centre 25 feet 6 inches above the springing line and the thickness of the arch ring at the crown is 4 feet. The spandrel walls are counterforted and are 10 feet high from the arch crown to the coping of the walls and the bridge is filled with earth on top of the arch ring between these walls. Expansion joints are provided at intervals across the bridge. The bridge is 32 feet 6 inches wide, and the height of the abutments from the rock foundation to the springing line is 5 feet.

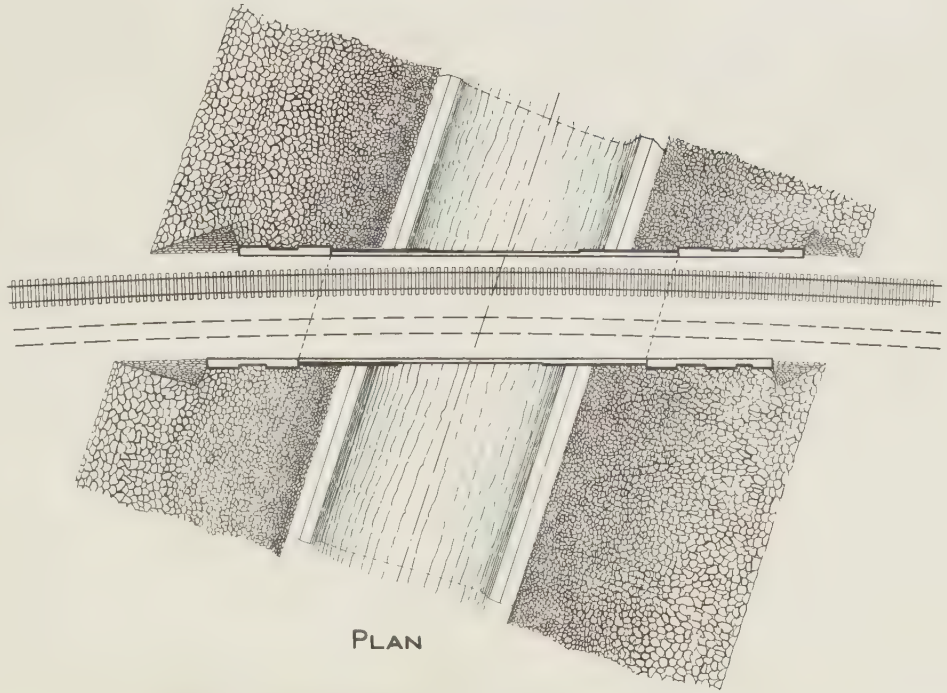
There is a temporary trestle approach to the arch at the west end consisting of two steel girder spans, one 19 feet 6 inches and the other 21 feet 7 inches long, supported by pile bent piers. This temporary approach span



SIDE ELEVATION PARALLEL TO RAILWAY



CROSS SECTION ON CENTRE LINE OF CANAL



PLAN

Scale of Feet

HYDRO-ELECTRIC INQUIRY COMMISSION

W. D. GREGORY-CHAIRMAN

QUEENSTON-CHIPPAWA POWER DEVELOPMENT

WABASH RAILROAD BRIDGE

Toronto, Oct. 12th., 1922. Made by [illegible] Checked by [illegible]

WALTER J. FRANCIS, C.E.,

CONSULTING ENGINEER

(J-141)

carries the track of the Wabash Railroad over the double track construction railway. No decision has yet been made as to the replacement of this temporary approach when the construction railway is dismantled.

The bridge is designed to carry Cooper's E-60 loading. The track crosses the bridge on a 3-degree curve and on a grade of 0.6 per cent. rising from east to west. The centre line of the bridge makes an angle with the centre line of the Canal of 72 degrees. The width of the bridge is 32 feet 6 inches, which provides for the addition of another track.

During the construction of the permanent structure the track of the Wabash Railroad was diverted over the Canal on a pile bent trestle. This temporary trestle was about 771 feet 6 inches long and a steel girder span 19 feet long provided a crossing of one track of the construction railway. The steel beams for the girder span were rented from the Grand Trunk Railway for $148.48 per annum. The excavation of the earth in the Canal prism at the site of the trestle was done by No. 2 electric shovel working from the north. As soon as the shovel had passed the diversion site, bents were erected on the rock surface and work on the trestle commenced. The railroad traffic was diverted over the temporary structure during the last week of November 1918, and the trestle was dismantled on completion of the permanent bridge.

The excavation of the rock for the permanent abutment foundations was commenced at the end of January 1919, and the formwork erection was started during the week ending March 1st, 1919. The concreting was commenced during the week ending April 26th, 1919, and the arch rings and abutments were completed on August 30th, 1919. All the concrete work was completed on September 27th, 1919. The concrete in the arch ring was poured in narrow strips about

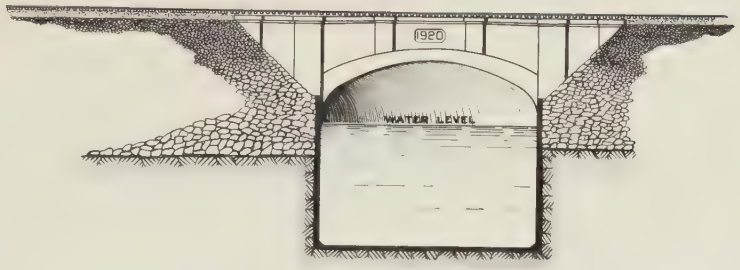
eight feet wide, this was insisted upon by the Grand Trunk Railway notwithstanding the protests of the Hydro-Electric Power Commission engineers.

The details of the construction and the design were agreed upon by the Grand Trunk Railway and the Hydro-Electric Power Commission on August 4th, 1917, and were similar to those outlined in the description of the Grand Trunk Railway and Michigan Central Railroad bridge which follows. As the centre line of the Wabash Railroad bridge was nearly at right angles to the centre line of the Canal the saw-tooth skew-back foundation construction, which was insisted upon by the railway companies for the Grand Trunk Railway and Michigan Central Railroad bridge, was omitted. It was agreed that a two-track bridge was to be provided for the Wabash Railroad.

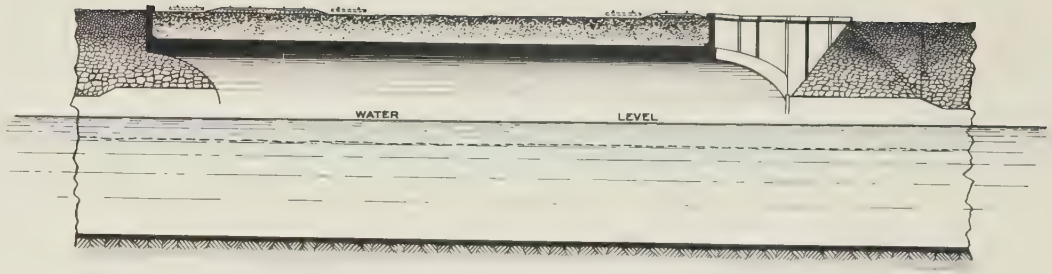
Grand Trunk Railway and Michigan Central Railroad Bridge.

The Grand Trunk Railway and Michigan Central Railroad bridge is located at the crossing of the Canal by the main line of the Grand Trunk Railway and the Niagara-on-the-Lake branch of the Michigan Central Railroad at about station 824+00. The location of the bridge is shown at "F" on the plan on page J-102, and the general plan and elevations are given on the drawing included as page J-144. The location of the track of the Michigan Central Railroad is shown at "24", and the tracks of the Grand Trunk Railway at "25", on the plan on page J-102.

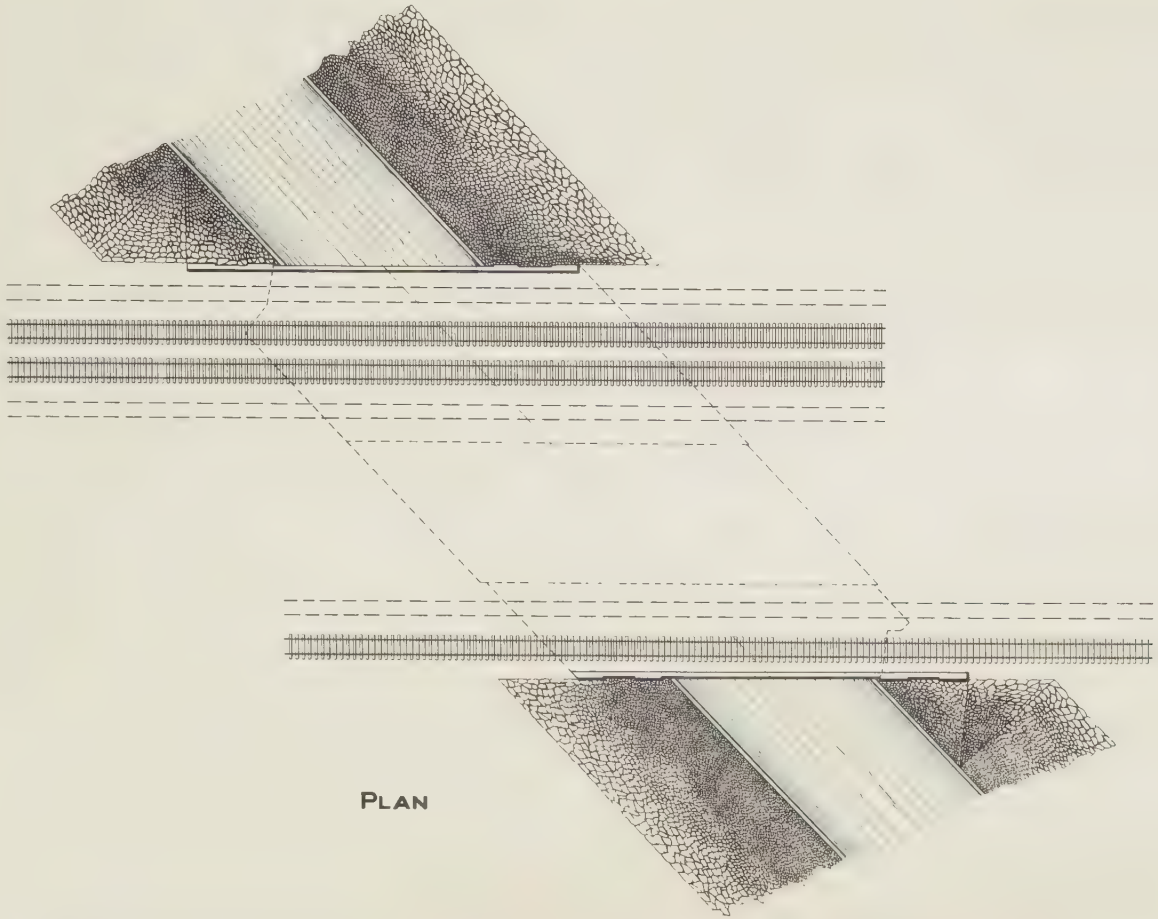
The bridge is a permanent structure and consists of a reinforced concrete earth-filled arch of 72-foot span resting on concrete gravity abutments of the "U" type, founded on solid rock. The arch rises at the centre 20 feet



SIDE ELEVATION PARALLEL TO RAILWAY.



CROSS SECTION ON CENTRE LINE OF CANAL.



PLAN

Scale of Feet

HYDRO-ELECTRIC INQUIRY COMMISSION

W. D. GREGORY-CHAIRMAN

QUEENSTON-CHIPPAWA POWER DEVELOPMENT

GRAND TRUNK RAILWAY AND MICHIGAN CENTRAL RAILROAD BRIDGE

Toronto, Oct. 12th., 1922. Made by [illegible] Checked by [illegible]

WALTER J. FRANCIS, C.E.,

CONSULTING ENGINEER

(J-144)

above the springing line and the thickness of the arch ring at the crown is 4 feet. The spandrel walls are 10 feet high from the arch crown to the coping of the walls and are counterforted. The bridge is filled with earth on top of the arch ring between the spandrel walls, and expansion joints are provided at intervals across the bridge. The bridge is 136 feet 8 inches wide and the height of the abutments from the rock foundation to the springing line is 8 feet.

The approach to the west end of the arch consists of two separate trestles carrying the tracks of the railways over the Hydro-Electric Power Commission construction railway. One trestle consists of two 26-foot steel girder spans for the two tracks of the Grand Trunk Railway, and the other of two 26-foot steel girder spans for the single track of the Michigan Central Railroad. No decision has yet been made as to the replacement of these temporary approaches when the construction railway is dismantled.

The bridge is designed to carry Cooper's E-60 loading. The tracks cross the bridge on a grade of 0.27 per cent. rising from south to north. The centre line of the bridge makes an angle with the centre line of the Canal of 46 degrees 45 minutes. The width of 136 feet 8 inches provides for future additional tracks on the Michigan Central Railroad and expansion of the Niagara Yard of the Grand Trunk Railway.

This structure was started prior to the completion of the Canal earth excavation at this point and it was constructed in three sections. The double-track line of the Grand Trunk Railway and the single-track line of the Michigan Central Railroad were first diverted to the strip between the two railways on a three-track pile trestle pending the construction of the permanent bridge on

The bridge is designed to carry Cooper's E-60 loading. The heaviest truck the bridge can safely carry is 240 tons. The maximum live or the bridge weight as made with the center line of the canal at 45 minutes 45 minutes. The width of 120 feet 8 inches provides for double railroad tracks on the Pittsburgh Coal Railway and operation of the bridge by the Ocean Shore Railway.

This structure was started prior to the completion of the Canal work. The construction at this point and it was constructed in three sections. The trestle work line of the Grand Trunk Railway and the single-track line of the Pittsburgh Coal Railway. The bridge is a high-level bascule type with a counterweight to balance the movable leaf. The bridge is 240 feet 8 inches long and 60 feet wide. The bridge is designed to carry Cooper's E-60 loading. The heaviest truck the bridge can safely carry is 240 tons. The maximum live or the bridge weight as made with the center line of the canal at 45 minutes 45 minutes. The width of 120 feet 8 inches provides for double railroad tracks on the Pittsburgh Coal Railway and operation of the bridge by the Ocean Shore Railway.

This structure was started prior to the completion of the Canal work. The construction at this point and it was constructed in three sections. The trestle work line of the Grand Trunk Railway and the single-track line of the Pittsburgh Coal Railway.

the original alignments. This temporary trestle was commenced during the week ending June 29th, 1918. The earth excavation in the Canal prism was then extended to this trestle from both sides through the original location of the tracks, and the excavation for the foundations of the abutments proceeded with.

The rock excavation was carried to a depth of about 12 feet below rock surface in order to obtain solid footings for the abutments. This excavation was commenced at the Michigan Central side of the bridge during the week ending August 16th, 1919. The portion of the bridge under the Michigan Central Railroad was built first, the concreting being commenced during the week ending October 11th, 1919, and construction of the portion under the Grand Trunk Railway followed.

After the completion of the concrete work on the two outside portions of the bridge, trestle bents were erected on the completed arches to carry the tracks on their original alignment. This permitted the removal of the three-track trestle and the excavation and construction of the central portion of the bridge to proceed. The last of the concrete on the central portion was deposited on June 15th, 1921. The outside portions were placed in strips of about 8 feet in width and, after many conferences with the engineers of the railways, it was decided finally to deposit the central portion in 16-foot rings.

The earth filling over the arch ring was done from the track level, the earth being obtained by a steam shovel from a borrow-pit near the bridge site.

The negotiations for the crossing were opened by the Hydro-Electric Power Commission with the Grand Trunk Railway and the Michigan Central Railroad in the latter part of 1916, and plans were submitted by the Hydraulic Department

of the Hydro-Electric Power Commission on December 16th, 1916, providing for a single arch span to carry three tracks, two of the Grand Trunk Railway and one of the Michigan Central Railroad. In this design the Michigan Central Railroad track was to have been diverted from its original position and moved adjacent to the Grand Trunk Railway tracks. The Michigan Central Railroad objected to any change in the alignment of their track for any structure and demanded a two-track roadway. During the discussions of the proposal the Grand Trunk Railway at first demanded an arch supporting their whole right-of-way, which is about 100 feet wide, and insisted on a concrete earth-filled arch. The plans produced by the Grand Trunk Railway at the discussions, showed a projected four-track road bed at the proposed bridge site. The Grand Trunk Railway would not recede from their demand for an earth-filled arch, and the Michigan Central Railroad followed the lead of the Grand Trunk Railway and demanded a design to carry Cooper's E-60 loading on their portion of bridge.

During the negotiations the Grand Trunk pointed out the possibility of their extending the Niagara Yards and the consequent occupation by tracks of their whole right-of-way. Accepting this, the combined bridge for the two roads is a measure of economy. The extra wings and spandrel walls which would be necessary with two bridges would contain 1570 cubic yards of concrete. Extra form work on spandrel walls and extra excavation for abutment wings for two separate bridges would leave a balance in favour of the combined bridge.

The arch was carried through with uniform section under the tracks of the Michigan Central Railroad. This is a branch line and uses Cooper's E-45 loading in the steel swing span bridge across the Welland River at Chippawa. A small saving might have been effected by reducing the section of the arch

ring under the Michigan Central Railroad tracks but the railroad requested that the same section as that under the Grand Trunk Railway be used. This was conceded under protest.

On the 7th of July, 1917, the Masonry Engineer of the Grand Trunk Railway wrote to the Hydro-Electric Power Commission demanding a factor of safety of 7½ in the concrete abutments and 5 in the arch for bending. He also asked that an addition of 25 per cent. to the dead load for impact be used in design computations. Since the minimum depth of earth over the crown is 10 feet, this was considered extravagant. A special saw-tooth footing for the skew-back on abutments was demanded on account of the angle which the centre line of the bridge makes with the centre line of the canal.

Stress investigations with the stipulated loadings, and considering the use of 1:2:4 concrete for an arch 4 feet thick, showed that the factor of safety was within the limit required by the Grand Trunk Railway. This information was communicated to the Grand Trunk Railway engineers, who suggested the addition of 3 inches of concrete, but they finally compromised by having the mixture changed to a 1:1½:3 concrete.

The negotiations were carried on until August 4th, 1917, when written agreements were signed by the Hydro-Electric Power Commission with the Grand Trunk Railway and the Michigan Central Railroad. The agreement with the Grand Trunk Railway and the Michigan Central Railroad, provided the usual clauses as to damage liabilities and fixed the maintenance and sinking fund charges on the Hydro-Electric Power Commission. Capitalization of maintenance and sinking fund amounts to about $18,000. Clause "T" of the agreement states "The Hydro-Electric Power Commission will so construct said permanent bridge that additional

tracks on the right-of-way of the Grand Trunk Railway may be laid at any time and will also at its own sole cost and charge, provide and maintain the bridge structures for additional tracks within the present right-of-way of the Grand Trunk Railway, whenever the Grand Trunk Railway require the Hydro-Electric Power Commission to do so."

Provision was also made that the work be done to the satisfaction of the Grand Trunk Railway, all plans to be submitted to the Grand Trunk Railway for approval, and the Grand Trunk Railway to be permitted to inspect all work, as owners.

The agreement with the Michigan Central Railroad was very similar and a continuous road-bed, i.e. continuous ballast over the bridge, was provided for.

That the whole design is very costly is beyond question. It should be said that at the time of construction steel plate was very hard to obtain and the Hydro-Electric Power Commission engineers submitted the concrete arch type as an expedient. The time element was of great importance during the negotiations, as the disposal railway "Y" was located between the Wabash and the Michigan Central Railroad-Grand Trunk Railway crossings. The under crossings of the disposal railway at the Grand Trunk Railway and Michigan Central Railroad tracks were therefore prerequisite to excavation of the Canal. Then, the demands of the railroads for the saw-tooth skew-back construction for abutment foundations and for concreting the arch in 8 foot sections (later, after much negotiating, increased to 16 feet) greatly increased the normal cost of the type adopted. From this latter increase the Hydro-Electric Power Commission engineers had no recourse, as the railroads were in a position to demand any design or method of construction; the necessity for the bridge being due to the construction

of the Canal.

Wire Crossings.

The following table gives a list of the wire crossings of the Welland River and the Canal. With the exception of two, these crossings were diverted in location or height by the Hydro-Electric Power Commission to provide for the span required to cross the Canal, and to provide clearance for the excavating machinery working on the Welland River and the Canal.

Table of Wire Crossings

Reference Number on Key Plan	Crossing	Location	Use
R.1.	International Railway	Chippawa	Light and Power
R.2.	Bell Telephone Co.	Chippawa	Telephone
R.3.	Canadian Niagara Power Co.	Chippawa	Power and Telephone
R.4.	Michigan Central R.R.	Chippawa	Railway Despatch
R.5.	Ontario Power Co.	Montrose	Power transmission
1.	Great Northwestern Telegraph and Michigan Central R.R.	Montrose	Telegraph
2.	Bell Telephone Co.	Montrose	Telephone
3.	Ontario Power Co.	Sta.53+00	Power transmission
4.	Toronto & Niagara Power Co.	Sta.66+00	Power transmission
5.	Ontario Power Co.	Convent Rd.	Power transmission
6.	Hydro-Electric Power Comm.	Sta.126+00	Power transmission
7.	Ontario Power Co.	Sta.144+00	Power and Telephone
8.	Stamford Hydro-Electric	Lundys Lane	Power and Light
9.	Bell Telephone Co. and Canadian Pacific Railway	Lundys Lane	Telephone & Telegraph
10.	Toronto & Niagara Power Co.	Sta.176+00	Power transmission
11.	Stamford Hydro-Electric	Winery Road	Power and Light
12.	Bell Telephone Co.	Winery Road	Telephone
13.	Stamford Hydro-Electric	Victoria Street	Power and Light
14.	Bell Telephone Co.	Victoria Street	Telephone

COPY

Table of Wire Crossings (continued)

Reference Number on Key Plan	Crossing	Location	Use
15.	Bell Telephone Co.	Portage Road	Telephone
16.	Niagara, St.Catharines & Toronto Railway	Sta.273+00	Power feeders
17.	Ontario Power Company	Thorold Road	Power transmission
18.	Great Northwestern Telegraph and Bell Telephone Co.	Thorold Road	Telephone
19.	Bell Telephone Co.	Stanley Street	Telephone
20.	Ontario Power Company	Stanley Street	Power transmission
21.	Wabash Railroad	Sta.310+00	Railway despatch
22.	Ontario Power Company	Sta.320+00	Telephone
23.	Ontario Power Company	Sta.320+00	Power transmission
26.	Great Northwestern Tel. Co.	Sta.325+00	Telegraph
27.	Stamford Hydro-Electric	Sta.351+00	Power transmission
28.	Ontario Power Company	Sta.430+00	Power transmission
29.	Hydro-Electric Power Comm.	Sta.441+00	Power transmission

A description of each of the above wire crossings, with a short history of its diversion or reconstruction at the Canal crossing, now follows.

International Railway Company Lighting Lines at Chippawa.

The location of the lighting wires of the International Railway Company at the crossing of the Welland River is shown at "R.1" on the plan on page J-102.

The original crossing consisted of two lighting wires carried across the Welland River as a single span, supported by poles on each bank, immediately north of the Bridgewater Street bridge in the Village of Chippawa. The International Railway Company supplied by these wires certain lighting

facilities to the east side of the river, which they were supposed to do under their original agreement with the Village of Chippawa.

The dredging of the Welland River necessitated the elevation of this line to clear the dredges operating at this point, and the construction of the new Bridgewater Street bridge necessitated their temporary diversion.

In June 1919 the line was diverted about 100 feet to the south of the bridge site and carried across the river as a single span supported by wooden towers of "H" frame construction on each bank. The clearance over water level of this diversion was originally 55 feet; but, after definite measurements of the dredge "Boone" in operation had been made, it was decided to increase the clearance to 70 feet. This was accomplished by raising the tower heights by adding to the "H" frame structure.

The line was restored to its original alignment in June 1922 with a clearance over water level of over 50 feet.

Bell Telephone Co. at Chippawa.

The location of the Bell Telephone Co. wire crossing at Chippawa is shown at "B.2" on the plan on page J-102. The original crossing consisted of thirty-two telephone lines carried across the Welland River as a single span, supported by poles on each bank, about 20 feet south of the Bridgewater Street bridge. The original clearance was not more than 30 feet above water level.

The construction of the new Bridgewater Street bridge necessitated the temporary diversion of this line and additional clearance was required for

the dredge "Boone" operating at this point.

The line was diverted in June, 1919, with the lighting wires of the International Railway Company and carried across the river on the same towers and with the same clearance as described for the lighting wire diversion above.

In June, 1922, a submarine cable carrying these telephone lines was laid across the river at the Bridgewater Street bridge and the temporary diversion dismantled.

Canadian Niagara Power Company at Chippewa.

The location of transmission and telephone lines of the Canadian Niagara Power Company is shown at "N.3" on the plan on page J-102.

The crossing consists of a power line of twelve wires, transmitting power at 22,000 volts from the generating station of the Canadian Niagara Power Company at Niagara Falls to Port Erie, and a telephone line of four wires. Both the power line and the telephone line were originally carried across the river as a single span supported by steel towers on each side of the river and, under agreement with the Department of Railways and Canals of Canada, provided a clearance above water level of 50 feet.

The dredging of the Welland River at the site of the Michigan Central Railroad bridge at Chippawa required the elevation of these lines to clear the dredge operating at this point, and arrangements were made with the Canadian Niagara Power Company for the Hydro-Electric Power Commission to elevate the tower structure 20 feet. This additional height necessitated new locations for the tower footings.

COPY FOR ENCLOSURE TO Mr. J. Allan Ross.

The work on the excavation for the footings was commenced on April 6th, 1921, and the towers were raised and the line reconnected on April 24th, 1921.

Since a space of 10 feet was required for the telephone line under the power lines it was considered advisable to divert the former rather than raise the power lines the additional amount. On October 6th, 1919, work was commenced on the diversion of the telephone line to a crossing 120 feet north of the tower line. This diversion is still in use, and carries the telephone line across the river as a single span supported at each side of the river by wooden poles.

Michigan Central Railroad Despatch Line at Chippawa.

The location of the permanent position of the Michigan Central Railroad despatch line crossing is shown at "R.4" on the plan on page J-102.

The original crossing consisted of a submarine cable carrying nine telegraph and telephone lines laid across the Welland River at the Michigan Central Railroad bridge at Chippawa.

The dredging of the Welland River necessitated the diversion of this cable crossing. The line was diverted as an overhead crossing 80 feet to the south of the bridge site in December, 1918. This crossing consists of a single span supported by wooden poles on each side of the river. The original clearance over the water level of 40 feet was raised, by adding to the poles, to 70 feet in December, 1920.

This diversion is still in use.

Great Northwestern Telegraph and Michigan Central Railroad Despatch Lines at Montrose.

The location of the Great Northwestern Telegraph and the Michigan Central Railroad lines is shown at "1" on the plan on page J-102.

The original line, constituting the Great Northwestern Telegraph and the Michigan Central Railroad despatch lines, consisted of nineteen wires carried on a single wooden pole line on the right-of-way of the Michigan Central Railroad. The clearance above ground level was 15 feet.

The construction of the permanent bridge of the Michigan Central Railroad at Montrose necessitated the diversion of this line pending the completion of the bridge.

The line was diverted to the north of the bridge site a distance of 65 feet during the week ending March 13th, 1920, a clearance above the ground of 60 feet being provided. On January 31st, 1921, the wires were carried across the Canal excavation in a box, which was placed on the temporary diversion trestle, and on August 7th, 1922, the line was replaced on its original alignment and carried on the permanent bridge in a temporary position, to be replaced in a permanent position at a later date.

Bell Telephone Co. at Chippewa Creek Road.

The location of the Bell Telephone Co. wire crossing is shown at "2" on the plan on page J-102.

The original line, constituting a telephone line of the Bell Telephone Co., consisted of a pair of wires twisted together and hung on a steel

messenger cable, providing 20 feet clearance above the ground.

The construction of the Chippawa Creek Road temporary bridge necessitated the diversion of this line pending the completion of the bridge, and it was also necessary to raise the wires to clear the dredge working on the excavation of the Canal.

On December 9th, 1919, the line was diverted 100 feet to the north of the bridge site and elevated to provide a clearance of 61 feet above the ground.

The line is still in this temporary diverted position. The poles supporting this line can be seen on the photograph of the Chippawa Creek Road temporary bridge on page J-113.

COPY

Ontario Power Company Transmission Line at Montrose and at Station 53+00.

The location of the crossing of the false cut at Montrose by the Ontario Power Company's transmission line is shown at "R.5" on the plan on page J-102, and the crossing of the Canal at about Canal chainage 53+00 by the same line is shown at "3" on the plan on page J-102.

The original location of this transmission line was on a private right-of-way of the Ontario Power Company, which ran from a point on the Welland River west of the junction of the power canal with the river, thence northeasterly and parallel to the Michigan Central Railroad to a point near the present location of the Michigan Central Railroad bridge at Montrose shown at "C" on key plan on page J-102; thence turning almost due north and following the location of the power canal to a road allowance at about canal chainage 53+00, thence turning easterly and following this road allowance to the

Winery Road. This right-of-way happened to fall within the limits of the canal excavation and construction railway location from the site of the present Michigan Central Railroad bridge at Montrose to the road allowance above mentioned.

Negotiations with the Ontario Power Company resulted in the reconstruction of this line from station 53+00 canal chainage. The new line crosses the Canal at this station and thence runs westerly along the road allowance to the Welland Road; thence southerly on the Welland Road to a point about 600 feet north of the Welland River, thence easterly across a property belonging to the Ontario Power Company to join the old line near the Welland River. This permanent diversion was completed by the Ontario Power Company prior to December 19th, 1919.

The proposal to cut a false channel from a point west of the Michigan Central Railroad bridge (over the Welland River at Montrose) from the River to the power canal by means of the dredge "Cyclone", made it necessary to provide a greater span and clearance for the passage of the dredge. Twin tower structures were constructed on each side of the proposed excavation, to carry the transmission lines over the proposed cut as a span of about 300 feet long, with a clearance above eventual water level of over 70 feet. This work was done during the week ending February 12th, 1921, and the line is still in this position.

The reconstruction of the line at the road allowance at station 53+00 included a crossing of the Canal at this point. It was necessary to raise the line from its original height of about 40 feet to a new height of about 70 feet above the ground, at the poles, in order to provide a clearance of about 60

feet at the centre of the span for the excavating machinery on the canal cut. This work was done on March 11th, 1920.

On August 9th, 1921, the span of the crossing at station 53+00 was increased to a width of 575 feet with a clearance at the centre of the span of 46 feet above the original ground level. This increase in the span length was made necessary by the new conditions arising from the decision to remove the earth prism by the dredge "Cyclone".

Toronto and Niagara Power Company at Station 66+00.

The location of the crossing of the Canal at about Canal station 66+00 by the power and telephone lines of the Toronto and Niagara Power Company is shown at "4" on the plan on page J-102.

The lines consist of two high tention power lines, one low tension power line, which at the time of commencing the Canal excavation at this point was not in commercial service, and one telephone line of the Power Company. The power lines are carried on steel towers and the telephone line on wooden poles. Each power line has six wires constituting two three-phase circuits and the telephone line consists of six wires. These lines connect the generating plant of the Toronto and Niagara Power Company at Niagara Falls with the City of Toronto. The original height above the ground of the transmission lines was 35 feet and of the telephone line 20 feet.

The original towers and poles were within the projected excavation lines of the Canal and it was therefore necessary to construct new towers and to re-locate the poles, both to provide for a greater span across the Canal and

to elevate the wires to clear the big electric shovel working on the rock surface. The new towers for the transmission lines were completed and the lines reconnected as a single span across the Canal with a clearance at the centre of 45 feet above the original ground surface, on October 6th, 1919. At the same time the telephone line was temporarily diverted to a crossing about 160 feet to the north of the original location. On November 15th, 1919, the telephone line was brought back to its original alignment and carried across the Canal as a single span supported by wooden poles, with a clearance at the centre of the span of 41 feet above the original ground level.

Owing to the danger of short circuits and the damage to the wires which might be caused by blasting in the vicinity of the transmission lines, two temporary alternative lines were installed on July 25th, 1921, one being located about 600 feet to the north of the permanent crossing and one about 600 feet to the south. During the period when blasting was going on in the vicinity of the original lines, the diverted lines were used, and power was transmitted over the permanent lines when blasting was being done near the diversions.

Ontario Power Company at Convent Road.

The location of the crossing of the Canal at approximately station 93+00 by the transmission and telephone lines of the Ontario Power Company is shown at "5" on the plan on page J-102.

The original lines consisted of two separate lines transmitting power at 12,000 and 30,000 volts, with a telephone line on the same poles as the

30,000-volt transmission line. These lines were of wood pole construction and crossed the Canal location at the Convent Road.

The construction of the Convent Road bridge and the necessary provision for clearance of the Canal excavating machinery required the diversion and elevation of these lines. The 12,000-volt line was diverted about 120 feet to the south of its original alignment on November 20th, 1919, and the 30,000-volt line was diverted about 130 feet to the north on October 27th, 1919, and the telephone lines were removed to a separate pole line 50 feet to the north of the 30,000-volt transmission line. A clearance of 55 feet above the original ground surface at canal centre was provided on all the lines.

In addition to the above lines a feeder for the sub-station of the Canal construction power plant and a 4,000-volt line from the sub-station to the Canal power line were carried across the Canal at this point, making five pole lines in all. To provide for blasting operations at the site, all the lines were provided with alternative crossings to the south of their permanent location, with the exception of the 4,000-volt line which was diverted to the north.

The construction of the alternative lines was commenced on May 21st, 1921, and was completed during the week ending June 4th, 1921.

Hydro-Electric Power Commission Transmission and Telephone Lines at Station 126+00

The location of the crossing of the Canal by the transmission and telephone lines of the Hydro-Electric Power Commission at about station 126+00, canal chainage, is shown at "6" on the plan on page J-102.

COPY

The following is a list of the lines at this crossing:-

(1) Steel tower line, 110,000-volt - 6 wires and 2 ground wires.

(2) Steel tower line, 110,000-volt - 6 wires and 2 ground wires.

(3) Steel tower line, 46,000-volt - 12 wires and 1 ground wire.

(4) Pole line, Telephone - 12 wires.

Concrete pedestals were constructed on each side of the Canal on the original alignment of the lines and new towers were erected on these pedestals to give a greater span and a clearance of 49 feet above the original ground level, for the transmission lines. The telephone line was also given a greater span and the same clearance. This work was completed during the week ending October 18th, 1919.

Alternative lines were constructed to provide for diversions of the high tension lines during blasting and they were completed during the week ending April 6th, 1921; a line being installed 609 feet to the north to provide for the two 110,000-volt lines and one 538 feet to the south for the 46,000-volt line. No alternative was provided for the telephone line.

Ontario Power Company's Transmission Line at Station 144+00.

The location of the Ontario Power Company's transmission line at the crossing of the Canal is shown at "7" on the plan on page J-102.

The line consists of six 12,000-volt transmission wires and one telephone line carried on the same poles. The original clearance above ground was 14 feet.

To provide for the excavation of the Canal, twin poles were installed at

each side of the Canal and the wires were carried across as a single span with 48 feet clearance above the original ground level. This work was carried out during the week ending September 20th, 1919.

Stamford Hydro-Electric System at Lundys Lane.

The original location of the Stamford Hydro-Electric System transmission line at the crossing of the Canal at about station 162+00 is shown at "8" on the plan on page J-102.

The line consists of one circuit of 4,000 volts and four wires of 220 volts with two telephone wires, all carried on a single pole line.

The line was diverted 460 feet to the north of its original location and raised to give a clearance of 45 feet above the original ground level in order to provide for excavation of the Canal. This work was completed on September 27th, 1919.

To provide for blasting at the site of this diversion, an alternative line was constructed on April 19th, 1921, on the original alignment at Lundys Lane and using the original poles at each side of the Canal.

Bell Telephone Co. and Canadian Pacific Railway Telegraph Lines at Lundys Lane.

The original location of the crossing of the Canal by the Bell Telephone Co. and the Canadian Pacific Railway telegraph lines at about station 162+00 is shown at "9" on the plan on page J-102.

The lines consist of eleven Canadian Pacific Railway telegraph wires and

COPY

six Bell Telephone wires, all carried on a single pole line with an original clearance of 43 feet above the ground surface.

On September 6th, 1919, the wires were diverted to a line about 460 feet to the north of the original location and were carried across the Canal as a single span with a clearance of 50 feet above the original ground level, supported by poles installed on each side of the Canal.

Toronto and Niagara Power Company at Station 178+00.

The location at the crossing of the Canal by the Toronto and Niagara Power Company's Transmission and Telephone lines at about Canal station 178 is shown at "10" on the plan on page J-102.

The lines consist of two 12,000-volt feeder circuits with one ground wire, and constituted a transmission line from the Toronto and Niagara Power Company to the Niagara, St. Catharines and Toronto Railway, with a telephone line, all carried on the same single poles, and having an original clearance above ground of 35 feet.

During the week ending September 9th, 1919, twin poles were installed at each side of the Canal on the original alignment, and the transmission wires were carried by these as a single span across the Canal with a clearance of 59 feet above the original ground surface. The telephone line was also carried by the same poles until February 5th, 1921, when it was diverted about 100 feet to the south to allow No. 12 shovel to operate at the original location. The telephone line was returned to the power line poles after the shovel had passed this point.

Stamford Hydro-Electric System at Winery Road.

The original location of the crossing of the Canal by the transmission lines of the Stamford Hydro-Electric system at about Canal station 192+00 is shown at "11" on the plan on page J-102.

This line consisted of one 3-wire transmission line carried on a single pole line, with a clearance of 28 feet. To provide for the erection of the temporary bridge at the Winery Road the line was diverted to the south of the original alignment a distance of 250 feet, and was carried across the Canal as a single span, with a central clearance of 51 feet, supported by poles at each side of the Canal. This work was commenced during the week ending June 28th, 1919, and was completed during the week ending July 19th, 1919.

Bell Telephone Company Line at Winery Road.

The original location of the crossing of the Canal by the telephone line of the Bell Telephone Co. at about Canal station 193+00 is shown at "12" on the plan on page J-102.

The line consisted of four telephone wires on a single wooden pole line with an original clearance of 20 feet. The construction of the bridge at the Winery Road necessitated the diversion of the line to a point 265 feet to the north of the bridge. The line was carried across the Canal as a single span with a clearance of 53 feet above the original ground surface, at the centre. The work on the diversion commenced on January 28th, and it was completed during the week ending July 12th, 1919.

Stamford Hydro-Electric System at Victoria Street.

The original location of the crossing of the Canal at about Canal station 233+00 by the transmission line of the Stamford Hydro-Electric system is shown at "13" on the plan on page J-102.

The line consisted of four wires carrying power at 2,200 volts and supported on a single pole line with a clearance of 27 feet. The construction of the Victoria Street temporary bridge necessitated the diversion of this line and it was moved 165 feet southerly from the original alignment. The wires are carried across the Canal as a single span supported by poles on each side of the Canal and provide a clearance of 50 feet above the original ground level at the centre of the span. The work was completed during the week ending January 21st, 1919.

Bell Telephone Co. at Victoria Street.

The original location of the crossing of the Canal by the telephone line of the Bell Telephone Co. at about Canal station 233+00 is shown at "14" on the plan on page J-102.

The line consists of a single-pole-line construction carrying four telephone wires. The original clearance was 22 feet. To provide for the construction of the Victoria Street temporary bridge the line was diverted 150 feet to the north of the original location and was raised in order to give a clearance of 47 feet above the original ground surface. The line crosses the Canal as a single span supported at each end by wooden poles.

The work on the diversion was completed during the week ending June 21st, 1919.

Bell Telephone Co. at the Portage Road.

The location of the crossing of the Canal at about station 250+00 by the line of the Bell Telephone Co. is shown at "15" on the plan on page J-102.

At the time that the construction of the Canal was commenced at this point, there was no Bell Telephone crossing to provide for, and this line has since been constructed by the Bell Telephone Co.

Niagara, St. Catharines & Toronto Railway.

The crossing of the Canal at about station 273+00 by the trolley and feeder lines of the Niagara, St. Catharines & Toronto Railway is shown at "16" on the plan on page J-102.

The line comprises the trolley line with its feeders and the telephone line of this electric railway and is made up as follows:-

5 feeder wires for trolley,

1 trolley wire,

4 telephone wires.

These are all carried on a single pole line paralleling the railway.

In the latter part of 1917 the line was diverted to the temporary diversion of the railway tracks pending construction of the permanent bridge. On the completion of the permanent structure the line was restored to its original alignment.

The Toronto and Niagara Power Company also maintained a 12,000-volt circuit of three wires on a single pole line at this point. This line was retained in its original position, the wires being raised to permit excavation to proceed beneath them, twin poles being installed at each end of the span across the Canal.

Ontario Power Company Transmission Line at the Thorold Road.

The original location of the crossing of the Canal by the transmission lines of the Ontario Power Company at about Canal station 286+00 is shown at "17" on the plan on page J-102.

The original line consisted of a single 3-wire circuit carrying 12,000 volts. The construction of the Thorold Road bridge necessitated the diversion of the line and it was moved 170 feet to the north of the bridge site. Twin poles were erected on each side of the Canal and the number of wires was changed from three to six. These were carried across as a single span providing a clearance of 82 feet at the Canal. This diversion was carried out in June, 1918.

Great Northwestern Telegraph Co. and Bell Telephone Co. Lines at Thorold Road.

The original crossing of the Canal by the lines of the Great Northwestern Telegraph Co. and the Bell Telephone Co. at approximately Canal station 289+00 is shown at "18" on the plan on page J-102.

These two lines consisted of two cables carried on a single pole line,

the Great Northwestern Telegraph cable containing nine wires and the Bell Telephone Co. cable having twenty-five pairs of wires. In June, 1918, the Bell Telephone Co. cable was diverted 250 feet to the north to provide for construction of the Thorold Road bridge. The line was elevated on the twin poles of the Ontario Power Company transmission line to provide clearance for the large shovels working on the Canal excavation.

On October 16th, 1918, the Great Northwestern Telegraph cable was also diverted to give a clearance of 81 feet over the Canal.

Bell Telephone Co. Line at Stanley Street.

The location of the crossing of the Canal at about station 298+00 by the line of the Bell Telephone Co. is shown at "19" on the plan on page J-102.

This line consisted of fifty-eight telephone wires constituting the trunk telephone lines from Niagara Falls to the west, and the local service lines, carried on a single pole line. Originally the line followed Stanley Street; but, as no crossing is to be provided for this street, the traffic being diverted across the Thorold Road bridge, the telephone line was diverted to cross the Canal at right angles at a point 400 feet to the north of the Thorold Road bridge. The line there follows the Stanley Street diversion to join the old line on Stanley Street west of the Canal. The line was carried across the Canal as a span supported by high twin poles on each bank, the work being done in September, 1918. Owing to danger from the blasting at this point, the exposed wires were replaced by a single cable in August, 1919.

Ontario Power Company Lines at Stanley Street.

The lines of the Ontario Power Company at Stanley Street consist of a single 3-wire circuit carrying 12,000 volts and two telephone wires, all carried on the same pole line. The location of the crossing of the Canal at about station 299+00 is shown at "20" on the plan on page J-102.

The line originally followed Stanley Street and was moved to a location crossing the Canal about 200 feet north of the Thorold Road bridge. The diversion was completed on October 28th, 1918, and the line has not yet been restored.

Wabash Railroad Telegraph Line at Station 310+00.

The location of the Wabash Railroad telegraph line at the crossing of the Canal is shown at "21" on the plan on page J-102.

The line consists of seven wires on a single pole line and constitutes the telegraph line of the Wabash Railroad. To provide for construction of the Wabash Railroad bridge the line was diverted 50 feet to the north on June 30th, 1918. It was raised on October 16th, 1918, to provide additional clearance for the canal excavation machinery and has since been restored to its original alignment on the new Wabash Railroad bridge.

Ontario Power Company Telephone Line at Station 320+00.

The location of the telephone line of the Ontario Power Company at the

crossing of the Canal is shown at "22" on the plan on page J-102.

The line consists of two telephone wires of the Ontario Power Company carried on a single pole line. It was moved 160 feet to the west of the original alignment and the wires were raised to give sufficient clearance for the canal excavation, during April, 1918.

Ontario Power Company High Tension Line at Station 320+00.

The Ontario Power Company's transmission line to Lockport consists of two steel tower lines carrying three wires each and transmitting power at 60,000 volts. The location of the permanent crossing of the Canal by these transmission lines is shown at "23" on the plan on page J-102.

The lines are at present temporarily diverted, the western line having been moved 140 feet to the west and the eastern line 320 feet to the east of the permanent crossing in April and May, 1918. The wires are carried across the Canal excavation as a single span supported by twin poles on each bank.

Great Northwestern Telegraph Line at Station 325+00.

The line of the Great Northwestern Telegraph Company crosses the Canal on the Grand Trunk Railway and Michigan Central Railroad bridge, and is shown at "25" on the plan on page J-102.

The line constitutes the Great Northwestern Telegraph line and consists of 16 wires on a single pole line. During the construction of the Grand Trunk Railway and Michigan Central Railroad bridge the wires were first diverted

300 feet to the east during the months of April and May, 1918, and were carried across the Canal on a long span supported at each end by twin poles. When the temporary trestle for the diversion of the railroads was completed the wires were carried across this trestle in a cable, and they were restored to their original alignment on the new bridge in August, 1922.

Stamford Hydro-Electric System at Station 351+00.

The line of the Stamford Hydro-Electric System consists of three wires supplying power to the Spanish Aero Car Company at the Whirlpool at 2,200 volts. The location of the crossing is shown at "27" on the plan on page J-102.

The line was raised in December, 1917, to provide a clearance of 35 feet above the construction railway tracks and has since remained in this position.

Ontario Power Company High Tension Line at Station 450+00.

The Ontario Power Company's high tension line also crosses the Canal at station 320+00, as described on page J-170, and consists of two steel tower lines each carrying a circuit of three wires transmitting power at 60,000 volts. The location of this crossing is shown at "28" on the plan on page J-102.

Two of the steel towers were in the way of the construction operations and wooden twin pole construction was substituted, the lines being carried across the Canal as a single span. In March, 1918, on moving No. 1 shovel from the Whirlpool section to the Forebay, it was found that the wires were

not sufficiently high to permit the shovel to pass. Wires were accordingly elevated to give a clearance of about 70 feet above the original ground surface.

The lines are now restored to their original location.

Hydro-Electric Power Commission Transmission Line.

The line of the Hydro-Electric Power Commission constitutes the high tension transmission line from the Queenston Power Plant of the Hydro-Electric Power Commission to Hamilton. The location of the crossing is shown at "29" on the plan on page J-102, and it crosses the Canal at approximately station 441+00.

This line was designed and built with provision for the crossing of the Canal, and no changes were necessary.

Walter J. Francis

Consulting Engineer.

Toronto, December 12th, 1922.